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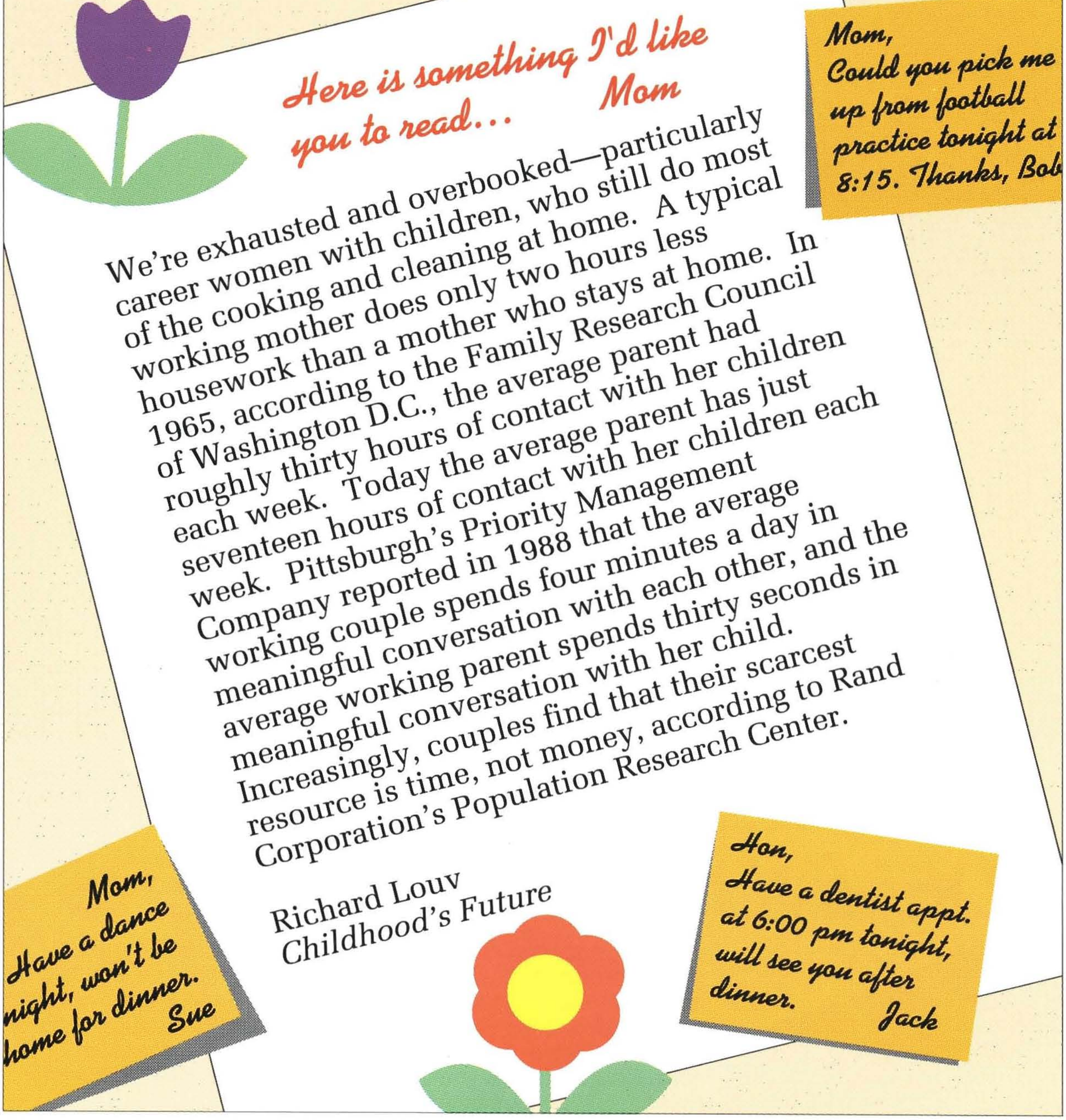

TIME IS FLYING NEVER TO RETURN.

—Virgil

DIFFERENTIATION MULTIPLICATION MOVEMENT

ASDC AMERICAN SOCIETY OF DENTISTRY FOR CHILDREN

JOURNAL OF DENTISTRY FOR CHILDREN

Volume 58 Number 2 March-April, 1991

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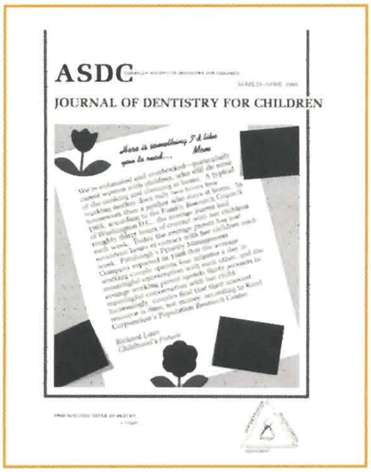

The patterns of modern family life have virtually erased opportunities for meaningful relationships between parents and their children.

CLINIC

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For the busy reader

Pits and fissures: morphology—page 97

The study is in two sections, the first for occlusal pit/fissure morphology and the second, for fissure-to-groove relationships on molars. On the occlusal surfaces of posterior teeth, these data suggest that fissures generally are not continuous; rather, they are more associations of adjacent pits separated by cols. Often under magnification stained areas are seen to be developmental grooves, not fissures; and that axial fissures are not continuous with occlusal surfaces, but are separated by a col surfaced with stained pellicle. A stained groove requires no treatment.

Requests for reprints should be directed to Dr. Owen F. Makinson, Department of Dentistry, The University of Adelaide, G.P.O. Box 498, Adelaide S.A. 5001, Australia.

Preservation of future options: restorative procedures on first permanent molars in children—page 104

The transitional dentition is divided into two stages, and is extremely important when considering indications for stainless steel crowns. Study models should be made of all patients who are to be treated with a stainless steel crown. Before the final preparation of a first permanent molar, the tooth should be restored with amalgam after all caries has been removed and the proper liners and/or bases placed. A flow chart is provided to give practitioners available options.

Requests for reprints should be directed to Dr. Richard M. Radcliffe, Associate Professor and Director, School of Dentistry, University Health Center, University of Detroit, 2985 E. Jefferson, Detroit, MI 48205.

Wear measurements in clinical studies of composite resin restorations in the posterior region: a review—page 109

In the posterior region, the composite resin restoration has not yet surpassed the amalgam generally used, due to significant problems such as the shrinkage that occurs in polymerization and the lower wear resistance compared with amalgam. Wear has been investigated both *in vitro* and *in vivo* by various research groups. This paper describes wear-evaluation methods of the last twenty years, and examines which of them would be capable of being applied in a longitudinal clinical study of the behavior of large numbers of restorations.

Requests for reprints should be directed to Dr. W.E. van Amerongen, Department of Pediatric Dentistry, Academic Centre for Dentistry Amsterdam, Louweswej 1, 1066 Amsterdam, The Netherlands.

Twenty-four-month clinical trial of visible-light-activated cavity liner in young permanent teeth—page 124

VLC-Dycal is an effective cavity liner for young permanent teeth in which all caries is removed. This material was also effective as a liner for indirect pulp capping; only two of thirteen IPC treated teeth failed, whereas direct pulp capping has always had a high failure rate regardless of material. After two years, VLC-Dycal had a 91 percent success rate; only five of fifty-four teeth were considered failures.

Requests for reprints should be directed to Dr. Lloyd H. Straffon, Department of Orthodontics and Pediatric Dentistry, The University of Michigan, Ann Arbor, MI 48109-1078.

Occlusal disturbances resulting from neglected submerged primary molars—page 129

The presence of primary molars in infraclusion—frequently called submerged primary molars—is a relatively common finding in children. Continued supervision of the developing occlusion is important. A rigid, periodic recall schedule should follow explanations given to the patient and parent. Two cases are described.

Requests for reprints should be directed to Dr. Yocheved Ben-Bassat, Department of Orthodontics, Hadassah Faculty of Dental Medicine, P.O. Box 1172, Jerusalem, Israel.

Hereditary opalescent dentine: variation in expression—page 134

Hereditary opalescent dentine is said to follow a pattern of nonsex-linked dominant inheritance. An interesting feature of this family, however, is that both girls are more severely affected than the boys. As the primary dentition is usually affected more severely than the permanent dentition, early diagnosis and treatment of patients is essential. Minor orthodontics and soft splints protect the dentition against wear, and occlusal adjustments will provide an even distribution of forces.

Requests for reprints should be directed to Dr. A.L. Symons, Dental School, Turbot Street, Brisbane 4000, Australia.

Do students in pediatric dentistry programs complete the course of training?—page 140

By 1985, nearly 400 first-year students withdrew from predoctoral dental programs, representing 8.2 percent of their entering class. Little or no attention has been directed to withdrawal rates from postdoctoral advanced dental education programs. This report includes programs in the eight recognized specialty areas. The difficulty is that there is a paucity of information about the students in advanced dental education programs.

Requests for reprints should be directed to Dr. H. Barry Waldman, Professor and Chairman, Department of Dental Health, School of Dental Medicine, State University of New York at Stony Brook, Stony Brook, NY 11794-8715.

There really are children in poor health—page 144

It is difficult to alter long-held perceptions and biases, even though we may know that changes in society are occurring. In many instances this tendency to place individuals or various demographic groups into convenient categories is reinforced and conditioned by portrayals in the media. Stereotyped images about health are not immune to this type of thinking, especially when it comes to children.

Requests for reprints should be directed to Dr. H. Barry Waldman, Professor and Chairman, Department of Dental Health, School of Dental Medicine, State University of New York at Stony Brook, Stony Brook, NY 11794-8715.

Acquired condylar hypoplasia: report of case—page 147

Requests for reprints should be directed to Dr. Roy G. Jerrell, Associate Professor of Pediatric Dentistry, Department of Pediatric Dentistry, University of Florida College of Dentistry, Box J-426, J. Hillis Miller Health Center, Gainesville, FL 32610.

Bilateral birooted maxillary primary canines: report of two cases—page 154

Requests for reprints should be directed to Dr. Mario E. Saravia, Assistant Professor, Department of Pediatric Dentistry, MCV School of Dentistry, Box 566, Richmond, VA 23298-0566.

Oral lesion in an infant: congenital epulis or transformation to ameloblastic fibroma?—page 156

Requests for reprints should be directed to Dr. Taha Ünal, Ege University, School of Dental Medicine, Bornova 35101, Izmir, Turkey.

Pits and fissures: morphology

Clinic

Max Rohr, DMD
Owen F. Makinson, BDS, DDS, FDSRCS, D OrthRCS, MS
Michael F. Burrow, MDS

Fissures have been defined as the discontinuity arising where two cusps fail to coalesce at the surface; a pit is a similar discontinuity at a particular site.[1] A developmental groove is but a shallow depression where two or more enamel lobes are joined. A fissure is often thought of as a continuous trough in the surface of the enamel; by serial sectioning or splitting of teeth it has been shown, however, that fissures vary in depth and tend to be a series of adjacent pits.[2-5]

Fissures and pits of human teeth are predilection sites for the development of dental caries. The influence for caries susceptibility of fissure width, cusp height, and of the surface shape adjacent to the fissure has been investigated.[6,7]

The objective of this study was to examine human posterior teeth for variation that might occur in fissures and the proportion between fissures and pits to developmental grooves. At the same time, it was decided to compare the degree of continuity of the occlusal fissures with axial fissures similar to the study of Fusayama and Kurosu with teeth extracted in Japan.[4]

MATERIAL AND METHODS

The study is in two sections, the first for occlusal fissure/pit morphology and the second for fissure-to-groove

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relationships on molars. In the first part, posterior teeth were split along the fissures for examination, and to test the accuracy of this method the teeth were subsequently sectioned.

Thirty-eight maxillary premolars and twelve mandibular molars were collected from the former Dental Department of the Royal Adelaide Hospital and general dental practitioners.

Following the removal of the roots, the crowns were stained with a modified Mallory's stain after Smale (Analine Blue-Orange G dissolved in 1 percent phosphotungstic acid without the prior 1 percent acid fuchsin) to demarcate the occlusal surface.[8] Subsequently on the coronal portion a channel was cut from the pulpal surface dentine, parallel with the fissure and toward the dentinoenamel junction. The tooth was split from the enamel to the dentine by squeezing together the gingival portions with pliers.

The split sections of teeth were then stained to mark the dentinoenamel junction. Each split surface was photographed to record the site of fracture and then the split sections of the crown were luted together before embedding in resin. From the photographs of the split sections of teeth, tracings were made at X 20 magnification of the fissures and the dentinoenamel junction.

After embedding in a resin block, the teeth were serially sectioned, giving usually six or seven sections for each premolar and ten for a molar. Thus, ten or twelve planes for each premolar and eighteen planes for a molar, perpendicular to the fissure, could be examined (Figure 1).

The second phase of this work was to examine axial surfaces of molars for fissures, pits and grooves. Human molar teeth were obtained in four groups as listed in Table 1.

The first sample (group A) was of molars with the "fissures" marked with a drawing lead tip sharpened to approximately 0.55 mm width. This was followed by splitting and staining (Figure 2) but only the noncarious fissures were counted in the study.

The second sample (group B) was of extracted teeth collected from the Oral Surgery clinic. The third series (group C) was from teeth collected by students and incorporated into operative techniques manikins. The last group (D) was from the Ramsay Smith Collection of Teeth in the Dental School of the University of Adelaide.

The samples were examined at low magnification using a stereo microscope and categorized into subgroups of groove, fissure, and pit combinations as indicated in graphed results.

Table 1 ☐ Specimens of molar teeth examined.

Specimen group	Upper molars	Lower molars
A. split and stained teeth	120	46
B. teeth from the Oral Surgery clinic	42	45
C. teeth in student mannikins	232	236
D. teeth in the Ramsey Smith collection	251	131
Totals	645	459

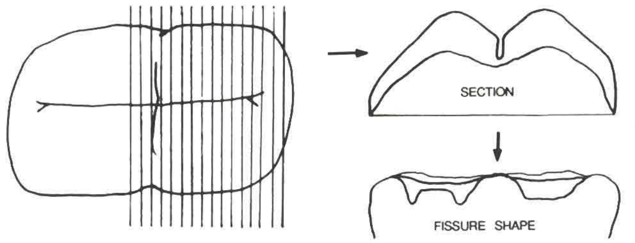

Figure 1. The sequence of deriving longitudinal fissure shape from a series of cross-sections.

RESULTS AND DISCUSSION

The sectioning of the split teeth showed that the position of the split occurs in the region at the bottom of a fissure as can be seen in the serial sections (Figure 3).

The position of the split relative to the fissure was classified into the following types (the split has not occurred in the fissure, due to a deviation of the end of the fissure from the main direction of the fissure):

Type 1. The split occurs at the bottom of a fissure.

Type 2. The split occurs at the bottom of one bifurcation of the base of a fissure.

Type 3. The split occurs at the side of the fissure.

Of the 712 surface sections, thirty-four sections from eleven teeth showed small areas of initial caries within a section of the fissure. The technique of splitting teeth along fissures appears to give a reasonably accurate picture of the general longitudinal form of fissures, assuming that this work on maxillary premolars and mandibular molars could be similarly duplicated on other teeth. Where the split occurs from within the fissure, it occurs from the base of the fissure in approximately 96 percent of instances. The minimal enamel thickness from the fissures to the dentinoenamel junction (Figure 4) was as follows:

- ☐ Maxillary premolars, mean 0.2 mm (range 0.05-0.5 mm).
- ☐ Mandibular molars, mean 0.33 mm (range 0-0.8 mm).

The shapes of fissures in maxillary premolars are given in Figure 5, which indicates the relative incidence of fissure troughs and pit systems. The end forms of fissures in maxillary premolars and mandibular molars are shown in Figure 6.

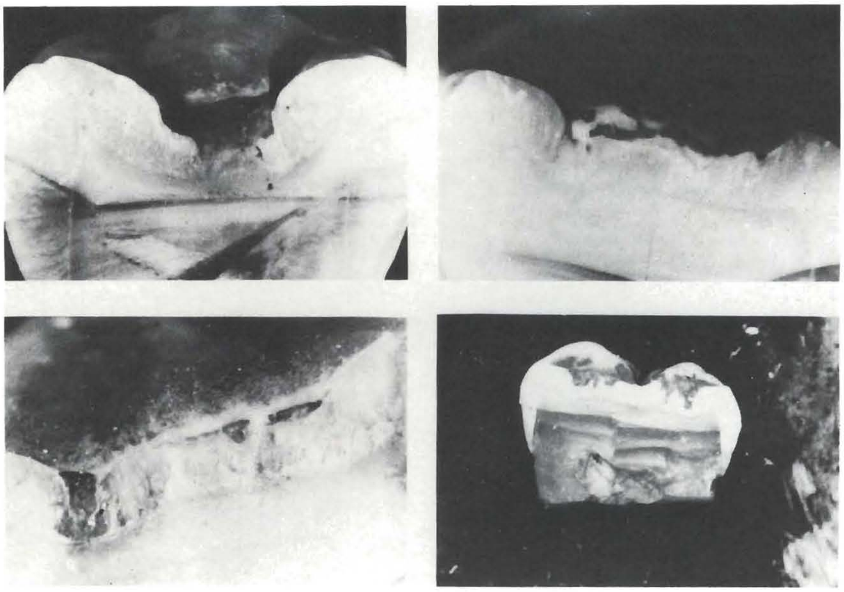

Figure 2. Teeth split and stained to show fissures (top) and pits (bottom). Note the organic remnants remaining within pits and fissures and the pellicle on the lower inclines of cusps.

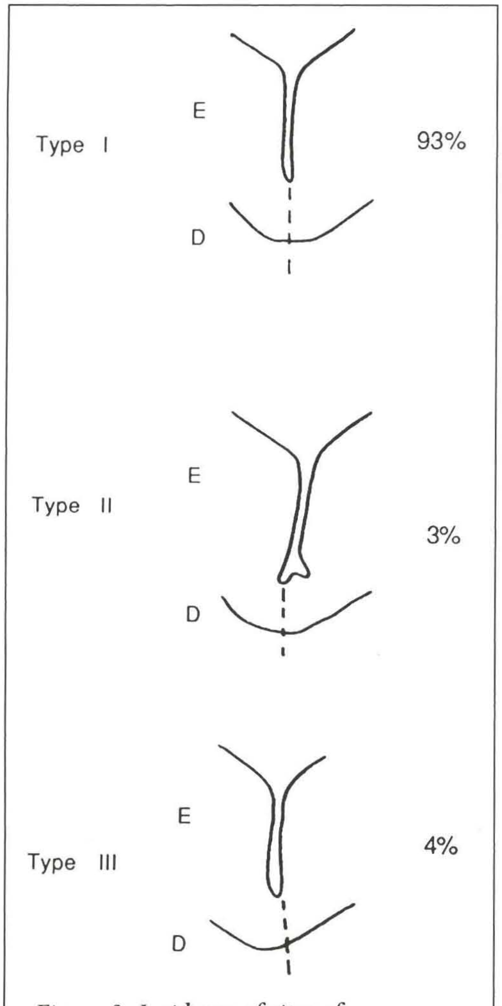

Figure 3. Incidence of sites of fracture relative to the fissure.

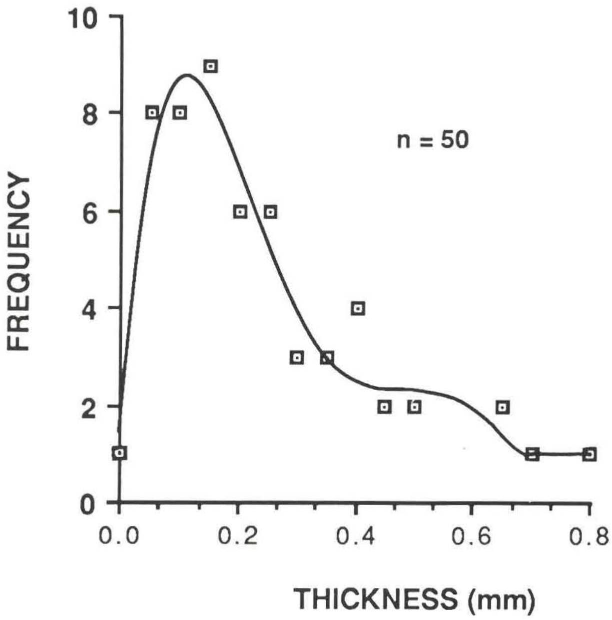

Figure 4. Enamel thickness below fissure termination.

From an examination of the split teeth and microscopic examination of unsplit teeth the following descriptions were derived.

- ☐ Pits and fissures have a considerable quantity of organic matter from the reduced enamel epithelium and the acquired pellicle. This often remains firmly attached to the enamel despite the acid processes used in the several trial stain systems in a pilot study (Figure 7).

> **Contents of pits and fissures include enamel epithelium and pellicle.**

☐ Looking into pits of dried teeth discloses that this organic sheath shrinks in a hollow form from a previously closely adherent layer to the fissure walls. This remains in place with traditional prophylaxis and at least in part with the air-water slurry system, and in spite of acid-etching methods in our samples of teeth; Garcia-Godoy and Medlock, from a sample of fourteen teeth, suggest all these remnants are removed.[7]

The nature of fissures has been described by Juhl, Gwinnett and Galil among others.[8,9] In these two studies, the fissure impregnating resins would seem to have penetrated into the hollow dried form of the organic sheath. The extent to which such material remained on the resin replicas is not known. It is sufficient to say that in our interpretation of their material, these two studies appear to show fissures as an association of pits rather than as continuous canyons.

In this study of splitting teeth along occlusal fissures, the essential nature of a fissure as a series of related pits is confirmed. The range of such associations is considerable as shown in Figure 8, where the pits are elongated and the connecting cols between the chasms might be regarded as the normal junction between cusp inclines. These connecting cols occur far more frequently perhaps than were previously recognized. Visually, the reason for this is that connecting cols are coated in pellicle material as are the lower inclines of the cusps (Figure 9). These connections of organic material may absorb considerable stain over the years; with little or no magnification the stained grooves (interconnecting cols) might be mistaken as continuities of depth in fissure canyons. This view of separated pits with considerable connections between cusps has implications for preventive measures using sealants.

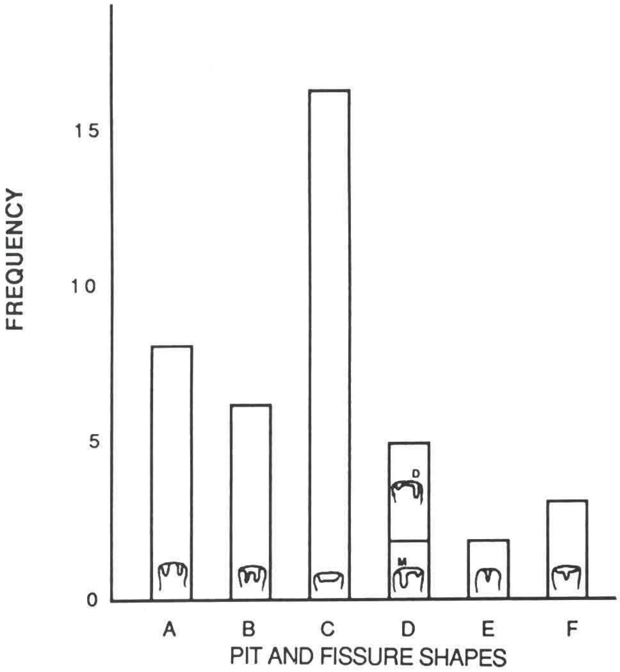

Figure 5. Pit and fissure incidences, mesiodistally in maxillary premolars. (A - two pits; B - two pits joined by a fissure; C - a fissure; D - a pit and a shallow; fissure E - a central pit; F - central pit within shallow fissure).

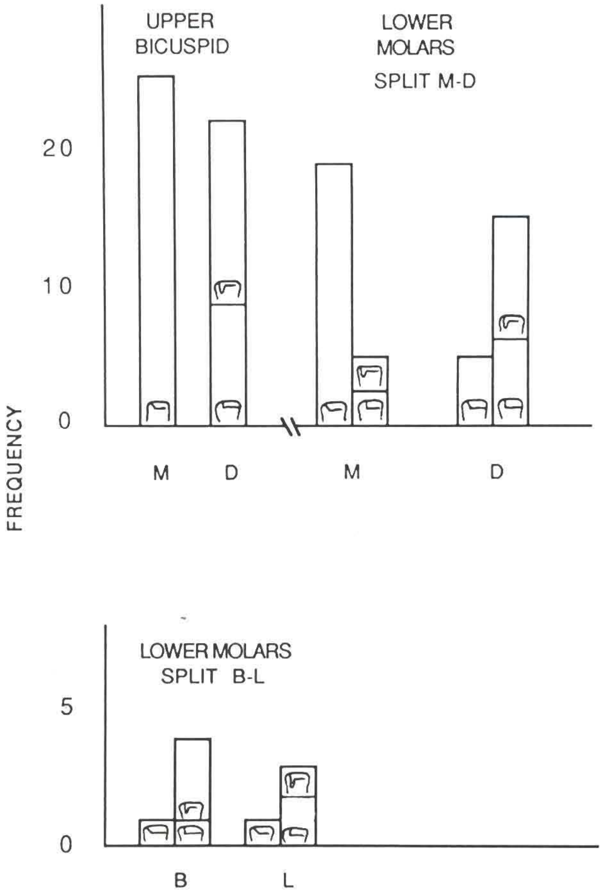

Figure 6. Incidence of various shapes at the ends of fissures. The forms are indicated in the inserts as sloping, a vertical pit or a vertical fissure end. (M - mesial, D - distal, B - buccal, L - lingual ends of fissures).

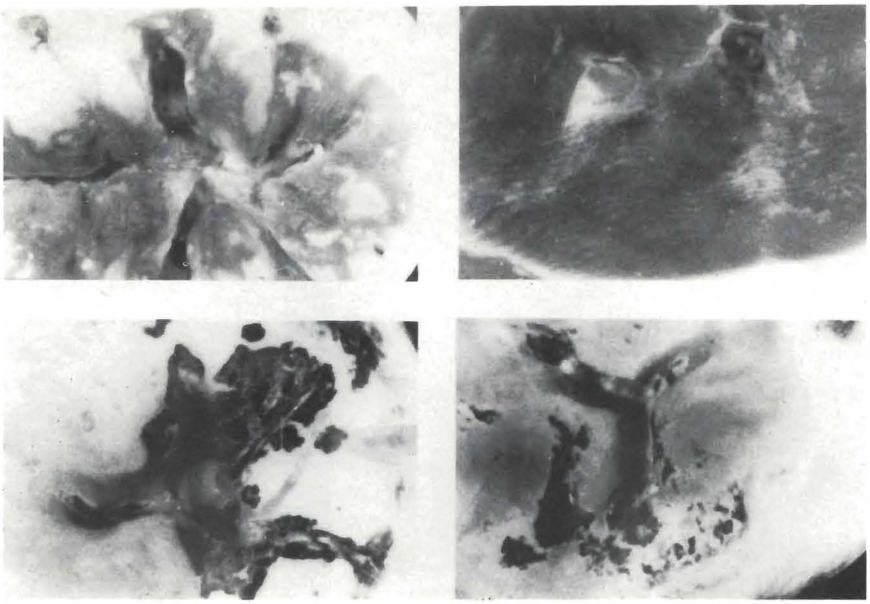

Figure 7. Organic remnants remaining within pits and fissures following prophylaxis and etching.

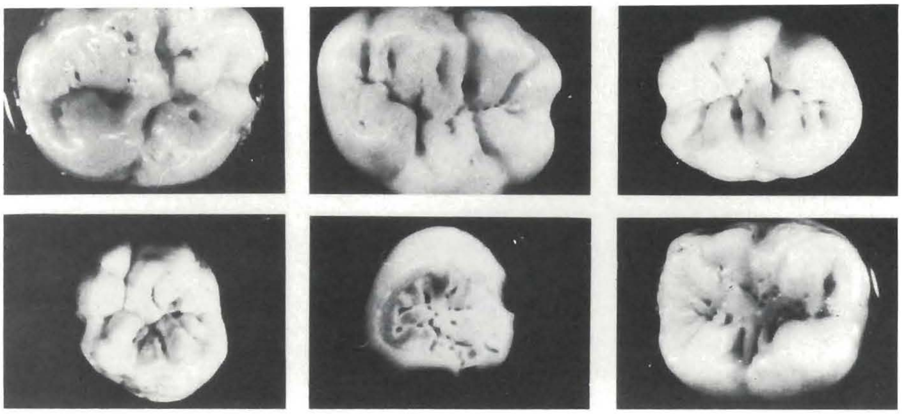

Figure 8. Occlusal surfaces of molar teeth indicating some of the range of association of pits to fissures.

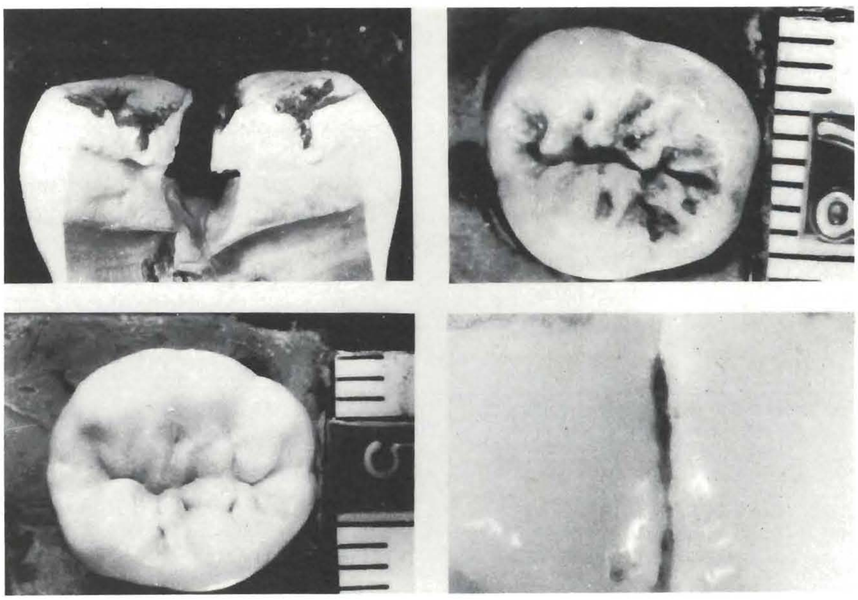

Figure 9. Stained pellicle located on lower cuspal inclines (top) and in developmental grooves imitating fissures (bottom).

For the results of the second series, that is, the study of the axial and occlusal surfaces of molars for pits and fissures relative to grooves, the data are treated in the following order:

☐ Maxillary molars—buccal and lingual areas.
☐ Mandibular molars—buccal, distobuccal and lingual areas.
☐ Occlusal fissures.

For the maxillary molars, the results are given in Figure 10. On the buccal surface a developmental groove was the common feature. The low incidence of fissures and of pits on those surfaces could be a result of such defects being eliminated by caries and operative procedures, and these specimens would then be more a sample of teeth relatively less prone to caries.

For this sample of maxillary molars, the incidence of fissures and of a groove associated with a pit was much higher on the lingual surface than on the buccal. The results from group A may differ in that it was possible to examine those teeth in split section as well as from above the enamel surface. Teeth in this group often had caries in the occlusal fissures, whereas caries was infrequent in the other samples. It could be argued, however, that the existence of fissures and pits are not accurately discerned by viewing from above the surface compared with examination of split specimens.

The results for the mandibular molars are given in Figure 11. The variation was greater in the middle region of the buccal surface than in the distobuccal area. In both instances developmental grooves predominated, however, with or without a terminal pit. On the lingual surfaces fissures and pits were rare.

Considering the occlusal surfaces of maxillary molars, fissures were more common than pits (teeth only from groups A and B). Fissures were again most common on the occlusal surfaces of mandibular molars, but with a higher incidence of pits (Figure 12).

The extension of fissures on occlusal surfaces to the axial surfaces—that is, the continuity of occlusal fissures to the axial surfaces—was measured (Table 2). In this study, the teeth were presumed to be mainly of caucasian origin. It was determined with the exception of the lingual surfaces of maxillary molars, few instances were found of continuity of the occlusal to axial fissures. The interruption of the occlusal fissure to the axial surface was by only a small enamel bridge as a short developmental groove. Frequently, what was thought to be an axial fissure, was found with magnification to be only a developmental groove, where cavity extension would be contraindicated in the present philosophy of preservative dentistry.[10]

Instances of isolated pits and fissures, often with an associated groove, were found, however, on the buccal of mandibular molars (7.7 percent) and on the lingual of maxillary molars (1.7 percent). Fusayama and Kuroso did not find such examples in their sample of teeth, presumably from mainly Japanese patients.[4]

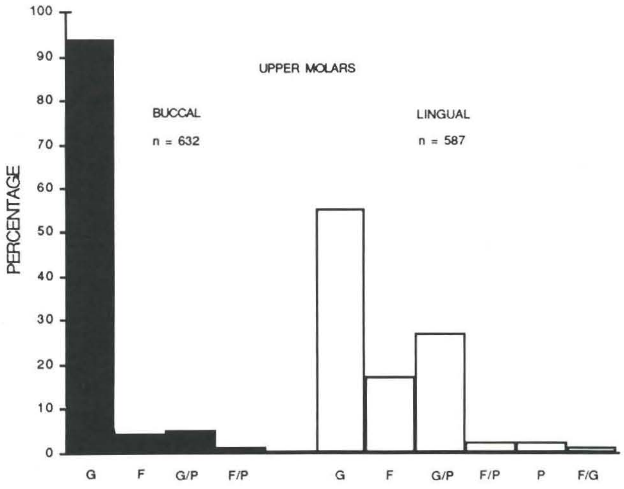

Figure 10. Incidence of grooves, fissures and pits; axial surfaces of maxillary molars.

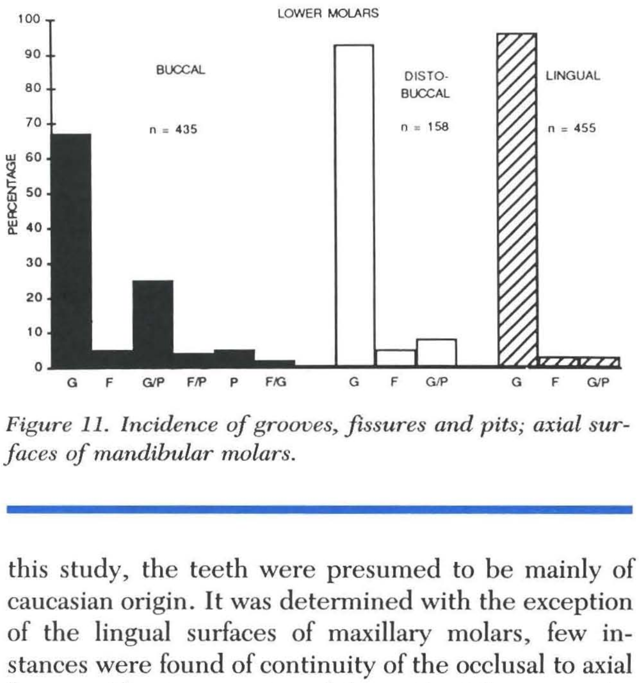

Figure 11. Incidence of grooves, fissures and pits; axial surfaces of mandibular molars.

Table 2 ☐ Continuity of occlusal into axial fissures.

	Sample size	Existence of axial fissure	Instance of continuity	Continuity percent of whole sample
Maxillary molars				
buccal	632	13	2	0.3
lingual	584	99	57	9.9
Mandibular molars				
buccal	422	13	6	1.4
distobuccal	158	3	0	0
lingual	444	4	1	0.2

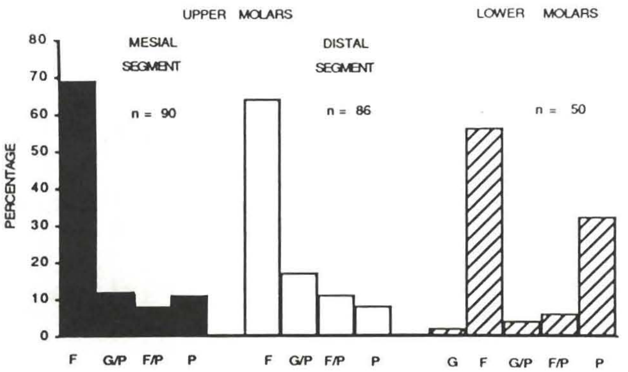

Figure 12. Incidence of grooves, fissures and pits; occlusal surfaces of molar teeth.

CONCLUSIONS

On the occlusal surfaces of posterior teeth, these data suggest that fissures are generally not continuous, but are more associations of adjacent pits separated by cols.

It has been routine practice in cavity preparation in molars to extend from occlusal fissures buccally and lingually into what appeared to be extensions of the occlusal fissures. There is a tendency to assume that stained areas on these axial surfaces are fissures and that such fissures are continuous with the occlusal fissures. Often under magnification the stained area is seen to be a developmental groove and not a fissure and that axial fissures are not continuous with occlusal surfaces but separated by a col covered with stained pellicle.

We wish to thank Mr. R. Pietrobon for his valuable assistance with the illustrations.

On the axial surfaces of molars the incidence of developmental grooves on the axial surfaces was higher than for fissures or pits.

The continuity of fissures from the occlusal to the axial crown surfaces was low and this accords with findings made in Japan.[4] Often, however, the occlusal and axial fissures were separated only by a short developmental groove. Thus in operative practice extension from one fissure to another would have been warranted using Black's philosophy, but now can be sealed with resin in this new minimal-intervention philosophy, recognizing that a stained groove requires no treatment.

REFERENCES

1. Boucher, C.L.: *Current clinical terminology*. St. Louis: The C.V. Mosby, Co., 1963.
2. Gillings, B. and Buonocore, M.G.: Enamel thickness in pits and fissures of human posterior teeth. J Dent Res, 39:675, July-August 1960.
3. Awazawa, Y.: Re-examination of the morphology of caries susceptible grooves in the premolar and molar. J Nihon Univ Sch Dent Vol 11, No. 1, March 1969.
4. Fusayama, T. and Kurosu, A.: Diagnosis and distribution of pits and fissures. J Pros Dent, 14:117-126, January-February 1964.
5. Makinson, O.F.: The morphology of fissures in the permanent human dentition. (Abstract) J Dent Res, 47: suppl. 6, 1019, 1968.
6. Garcia-Godoy, F. and Medlock, J.W.: An SEM study of the effects of air-polishing on fissure surfaces. Quin Int, 19:465-467, 1988.
7. Juhl, M.: Three dimensional replicas of pit and fissure morphology in human teeth. Scand J Dent Res, 91:90-95, 1983.
8. Smale, D.E.: Preparation and staining of ground sections of teeth: with special reference to the enamel. Brit Dent J, 100:244-248, May 1, 1956.
9. Galil, K.A. and Gwinnett, A.J.: Three dimensional replicas of pits and fissures in human teeth: scanning electron microscope study. Archs Oral Biol, 20:493-499, 1975.
10. Elderton, R.J.: Changing scene in restorative dentistry. Brit Dent J, 164:263-264, April 23, 1988.

THE CHILD CANNOT WAIT

Many things we need can wait. The child cannot. Right now his hip bones are being formed, his blood is being made, his senses are being developed. To him we cannot say tomorrow.

Mistral (Chilean poet)

Preservation of future options: restorative procedures on first permanent molars in children

Richard M. Radcliffe, DDS, MS
Claire L. Cullen, DMD

The use of preformed stainless steel crowns as interim restorations has been well documented in dental literature.[1,2] The purpose of this article is to present a technique that will preserve future permanent restorative options, when faced with the problem of restoring permanent posterior teeth in the transitional dentition.

The preparation of permanent teeth for a stainless steel crown, as described in the literature and taught in most dental schools, requires minimal reduction of the tooth.[2] If the entire tooth is prepared for a crown, future restorative procedures are limited to full cast crowns or porcelain-fused-to-metal crowns. The options for placing a cast onlay or a porcelain onlay as permanent restorations are precluded at a very young age, unless a minimal reduction is made.

INDICATIONS FOR STAINLESS STEEL CROWNS

Stainless steel crowns are indicated for permanent teeth for multiple reasons. Permanent teeth treated with such procedures as indirect pulp capping, direct pulp capping, pulpotomies, apexification procedures, and root canal therapy are all potential candidates for stainless steel crowns as interim restorations (Figures 1,2).

Permanent molars and premolars may erupt with hereditary enamel defects such as the various forms of amelogenesis imperfecta (hypoplasia, hypocalcification, and hypomaturation).[3] The degree and extent of the enamel hypoplasia will determine the course of treatment for these patients. The majority of these defects are observable and present in the primary dentition; parents should be advised, therefore, of the strong possibility that the permanent teeth will be involved also. These patients may present with mild involvement, where one could consider the use of pit-and-fissure sealants. If there is moderate involvement, consider the use of amalgam and/or composite restorations. With gross involvement, the use of stainless steel crowns is indicated. The proper use and placement of stainless steel crowns will preserve these permanent teeth until such time as cast restorations are feasible.

Special patients with physical, developmental, and emotional disorders may be candidates for stainless steel crowns in order to preserve the permanent dentition for prolonged periods of time. The decision to place permanent cast restorations will depend upon the severity and prognosis of the disorders presented by the patient.

The transitional dentition is divided into two stages and is extremely important when considering indications for stainless steel crowns.[4] Stage one exists when the four first permanent molars and the eight permanent anterior teeth have erupted. This stage occurs between the ages of five to eight years. Usually upon eruption the roots of the permanent teeth are from a half to three quarters formed. Stage two is defined as

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The transitional dentition is divided in two stages.

the period between the ages of nine years and thirteen years, when the premolars and second permanent molars are erupting. Maintenance of the mesiodistal width of the first permanent molars is critical during this stage; stainless steel crowns are indicated, therefore, for grossly involved teeth.

BEFORE PREPARATION FOR THE STEEL CROWN IS BEGUN

Radiographs

Routine bitewing and periapical radiographs should be studied to determine the amount of decay and its proximity to the dental pulp, the thickness of enamel present, and the relative positions of the unerupted second premolars and second permanent molars to the erupted first permanent molar (Figures 3,4). In addition, the periapical radiograph is useful in determining any periapical morbidity, and the degree to which apical closure has been completed.

Study models

Study models should be made of all patients who are to be treated with a stainless steel crown. Study models will provide important information, including interarch inspection of occlusion. The mesiodistal dimensions of the first permanent molars can be measured on the study casts. During stage one of the transitional dentition, the first permanent molars usually have erupted in an end to end molar relationship (Angle). This is the time, with properly occluded study models, to determine whether any occlusal adjustments should be made before the preparation of the teeth for stainless steel crowns (e.g. supraeruption).

Figure 1. Permanent molar requiring root canal therapy in eleven-year-old patient.

Figure 2. Completed root canal therapy, with a large, poorly contoured, amalgam restoration.

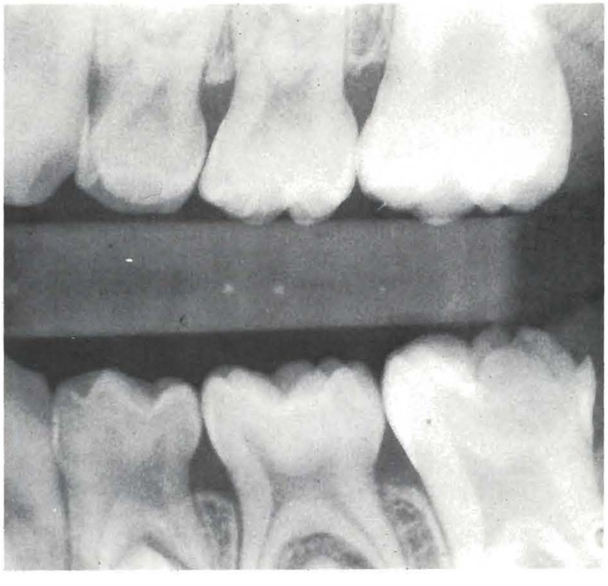

Figure 3. Bitewing radiograph is used to assess thickness of enamel and extent of caries.

During the second stage of the transitional dentition, the mandibular first permanent molar will shift mesially from an end- to-end relationship to Angle Class I. This shift is accommodated by the space gained from the replacement of the primary canines and molars by the premolars and permanent canines. The combined mesiodistal dimension of the primary molars and canine is usually 1.3 mm greater in the maxillary arch and 3.1 mm greater in the mandibular arch than the sum of the mesio-distal widths of the permanent canine and premolars. This discrepancy between the transitional dentition and the permanent dentition is known as the leeway space. In addition, the second permanent molar exerts a mesial force on the first permanent molar, driving the first permanent molars mesially.[5] The mesiodistal width of the first permanent molars is, therefore, of vital importance. Overcontouring of stainless steel crown can violate the leeway space, which should be preserved to accommodate the late mesial shift of the first permanent molar (Figures 5,6).

Before the final preparation of a first permanent molar for a stainless steel crown, we recommend that the tooth be restored with amalgam, after all caries has been removed and the proper liners and/or bases placed. A flow chart is presented to give practitioners available options (Table). During stage one, all treatment should be directed toward successful apical closure of the roots of the first permanent molars. During stage two, the critical factors are the preservation of and/or reestablishment of the proper mesiodistal width of the first permanent molar.

Figure 4. Periapical radiograph shows the development and position of the unerupted premolar and second permanent molar.

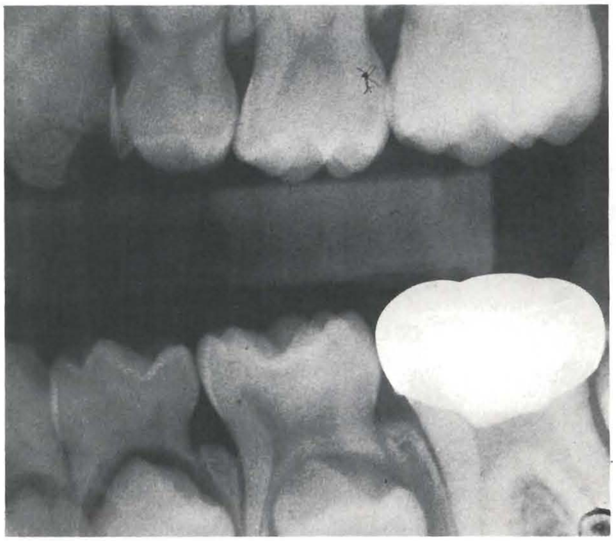

Figure 5. Overcontouring of the stainless steel crown results in loss of leeway space.

Table □ Restorative options in the transitional dentition.

Stage 1 — Caries removed

- No exposure ▼ Liners/Bases ▼ Pins, if necessary ▼ Amalgam restoration
- Exposure
  - Vital ▼ Pulpotomy
  - Nonvital ▼ Apexification
  - ▼ Temporary S.S. Crown ▼ Root canal therapy ▼ Prefabricated post (pins, if necessary) ▼ Amalgam restoration

Stage 2 — Caries removed

- No exposure ▼ Liners/Bases ▼ Pins, if necessary ▼ Amalgam restoration
- Exposure
  - Vital ▼ Pulp capping ▼ Liners/Bases ▼ Pins, if necessary ▼ Amalgam restoration
  - Nonvital ▼ R.C.T. ▼ Prefabricated post ▼ Pins, if necessary ▼ Amalgam restoration

Figure 6. Undercontouring of the stainless steel crown results in entrapment of the second permanent molar.

PREPARATION FOR A STAINLESS STEEL CROWN

Step 1

Occlusal reduction of 1.0 mm to 1.5 mm is accomplished by placing a 169 L tapered fissure bur in a high-speed, water-cooled handpiece. Depth cuts are useful to gauge the amount of occlusal reduction and to follow the cuspal outlines, producing an accurate, uniform occlusal reduction (Figure 7).

Step 2

The proximal reduction is accomplished using the 169L bur in a high-speed, water-cooled handpiece. The bur is held parallel to the long axis of the tooth and a slice preparation is cut, extending from the buccal to the lingual line angles. The tip of the bur should be positioned to create a feather edge finishing line at the height of the gingival papillae interproximally. Do not cut a shoulder preparation or extend the finishing line into the gingival sulcus (Figure 7).

Step 3

The third step is to cut a functional cusp bevel. The functional cusp is the lingual cusp on maxillary posterior teeth and the buccal cusp on mandibular posterior teeth. At this point, the proximal occlusal line angles and the buccal and lingual line angles are gently rounded and smoothed, which completes the preparation (Figure 7). It should be noted that the preparation is con-

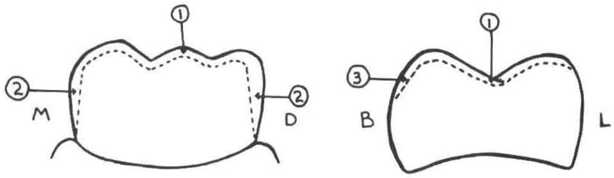

Figure 7. Steps in the preparation of a permanent molar for a stainless steel crown: Step 1: Occlusal reduction; Step 2: Proximal reduction; Step 3: Functional cusp bevel.

fined to the enamel of the tooth and/or the amalgam core. The future options for placing permanent castings (e.g. porcelain onlay, cast gold onlay, cast full crown, and porcelain-fused-to-metal crowns) are preserved and the dentist is not limited as far as the selection of a permanent restorative procedure.

TECHNIQUE FOR PORCELAIN ONLAY PREPARATION

Conversion of the stainless steel crown preparation to a porcelain onlay preparation is a simple procedure, assuming the stainless steel crown remained intact and allowed no leakage. Evidence of leakage upon removal of the stainless steel crown may include frank caries or decalcification of the enamel. Severe decalcification will require the fabrication of a cast full crown or a porcelain- fused-to-metal crown as a permanent restoration.

Occlusal reduction for a porcelain onlay

When overlaying cusps with porcelain sufficient occlusal reduction must be accomplished to provide room for enough bulk of porcelain to withstand occlusal forces. For a permanent first molar, the occlusal reduction of the functional cusp must be a minimum of 2.0 mm. Original occlusal reduction was from 1.0 mm to 1.5 mm. Occlusal reduction will be confined, therefore, to the functional cusp area, which should be reduced an additional 0.5 to 1.0 mm. The central fossa area and the nonfunctional cusp have also been originally reduced 1.0 mm - 1.5 mm. A bulk of porcelain of 1.5 mm is sufficient in these areas, so that minimum reduction is required in these areas.

Proximal preparation

A proximal slot is prepared on the mesial and distal surfaces, which had been previously sliced during the

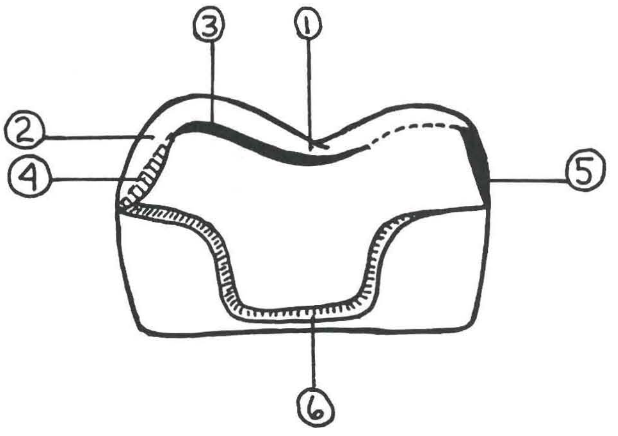

Figure 8. Porcelain onlay preparation: 1, original occlusal reduction for stainless steel crown; 2, original functional cusp bevel; 3, additional occlusal reduction (0.5-1 mm); 4, heavy chamfer on buccal functional cusps; 5, long bevel on lingual nonfunctional cusps; 6, proximal box joins the buccal and lingual preparations.

preparation for the stainless steel crown. The gingival floor of the proximal box should be approximately 1 mm in width and proximal walls should diverge 15°-20° toward the occlusal.

Buccal and lingual preparation

On a first permanent mandibular molar the functional cusp is the buccal cusp. A deep chamfer is cut on the buccal surface to join with the mesioproximal wall and the distoproximal wall of the proximal slot. The lingual cusp in this case is the nonfunctional cusp. The lingual is prepared by placing a long bevel that also extends from the mesiolingual proximal box to the distolingual proximal box. All internal line angles and point angles must be rounded (Figure 8).

REFERENCES

1. Croll, T.P.: Permanent molar stainless steel crown restoration. Quintessence Int, 18:313-321, May 1987.
2. Waggoner, W.F.: Restorative dentistry for the primary dentition. In *Pediatric dentistry infancy through adolescence.* Philadelphia: W.B. Saunders Co., 1988, pp 244-248.
3. Winter, G.B. and Brook, A.H.: Enamel hypoplasia and anomalies of the enamel. Dent Clin North Am, 19:3-24, January 1975.
4. van der Linden, F.P.: *Development of the dentition.* Chicago: Quintessence Publishing Co., 1983, pp 33-54.
5. Baume, L.J.: Physiologic tooth migration and its significance for the development of occlusion. II. The biogenesis of accessional dentition. J Dent Res, 29:331-337, April 1950.

UNSUPERVISED CHILDREN IN VEHICLES

Within the 24-month period of study (April 1987 to March 1989), nine cases were identified of children less than 15 years of age who were in a motor vehicle unsupervised and whose actions caused subsequent injuries either to themselves or to other children or adults. The age of the child setting the vehicle in motion ranged from 25 months to 10 years; the mean age was 5.5 years. The age of the injured child was 19 months to 4 7/12 years; the mean age was 3.7 years.

All of the children sustained multiple injuries. The most common anatomic sites of injury were the head or face and lower extremity. Three children sustained severe intracranial injuries—decapitation, brain crush, and skull fracture with intracranial hemorrhage. Two children had lower extremity fractures and one child sustained blunt thoracic trauma resulting in traumatic asphyxia. All of the other injuries involved abrasions and contusions.

Agran, P. *et al.*: Unsupervised children in vehicles: a risk for pediatric trauma. Pediatr, 87: 70–73, January 1991.

Wear measurements in clinical studies of composite resin restorations in the posterior region: a review

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W.E. van Amerongen

In recent decades, use of the synthetic composite resin introduced by Bowen has grown greatly in restorative dentistry.[1] In combination with the acid-etch technique described by Buonocore, the composite resin restoration appears to possess much better aesthetic and mechanical properties when used in the anterior teeth than the silicate cements, which were formerly frequently used.[2] In the posterior region, however, the composite has not yet surpassed the amalgam generally used up to the present. The reasons for this are the precise handling of the material required of the dental practitioner and the physical/chemical properties of the composite resin, with the most significant problems being the shrinkage that occurs in polymerization and the lower wear resistance in comparison with amalgam.[3-6]

Wear has been investigated both *in vitro* and *in vivo* by various research groups. Different materials wear through different mechanisms, however, so that laboratory tests of wear only give a good basis for comparison for materials possessing the same wear mechanism.[7-9] The predictive value of numerous laboratory experiments concerning the wear behavior of composite resin restorations in the oral environment appeared to be small; it is for this reason that a great deal of *in vivo* research was conducted on the subject of resistance to wear of composite resin restorations, although clinical research is costly in terms of time and money.[8,10-14] Since in the process a difference was found between the surface changes in contact free areas and in occlusal contact areas, something which is almost never simultaneously studied in the laboratory, this worked in the favor of clinical research.

Over the course of the years different techniques have been developed to determine the extent of loss of material in posterior composite resin restorations functioning in the mouth. This development ran in parallel with the improvement of the physical properties of the composite and the improvement of nondestructive methods of measurement. The aim of this article is to describe wear evaluation methods of the past twenty years and to examine which of them would be capable of being applied in a longitudinal clinical study of the behavior of large numbers of restorations. For this purpose methods are only described where evaluations are made of restorations fitted to natural teeth functioning in the mouth, and not to denture teeth or removable crowns/bridges. The methods' inaccuracies of measurement are not stated. The reason for this is that measurement errors are reported by the various authors in different ways, i.e. in volume percentages, in absolute or percentile vertical measurement, as an error in the method of measurement as a whole, or of individual parts. There is no agreement between authors on this point.

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This article describes wear evaluation methods of the past twenty years.

DIRECT CLINICAL EVALUATION

The studies of the behavior of posterior composite resin restorations that were conducted in the seventies primarily made use of the clinical evaluation criteria described in the United States Public Health Service (USPHS) method of Cvar and Ryge.[15,16] This evaluation system, which is in accordance with the sequence of decisions concerning the replacement of restorations by the dental practitioner, evaluates restorations for marginal adaptation, anatomic form, color match with the surrounding enamel, and cavosurface marginal discoloration. Trained and standardized researchers evaluate the restorations at fixed time intervals with the aid of mirror, dental probe and operating lamp.[17] A few researchers, compelled by circumstances, made use of modified versions of these criteria, but this does somewhat detract from the direct comparability of the different studies.[18,19]

Wear evaluation is theoretically to be found in the combination of the factors, marginal adaptation and anatomic form. Since the change in anatomic form, with a time interval of a year, for example, is difficult to evaluate, the adaptation is the most determining factor in the clinical situation. The three-point scale for adaptation consists of

- ☐ Alpha = explorer does not catch when drawing across margins.
- ☐ Bravo = explorer catches (crevice), but no dentin exposed.
- ☐ Charlie = explorer penetrating a crevice, dentin exposed.

There is talk of wear when the evaluation changes from Alpha to Bravo or Charlie.

Using these clinical criteria, in 1971 the research group of Phillips came to the conclusion after a year of research that regarding wear, composite should be comparable with amalgam.[20] In later reports, and also from other studies, however, the inferior wear resistance of conventional, self-curing composite became evident.[10,21-25] According to Leinfelder, this contradiction results from the limited discrimination capacity of the method.[26] It was calculated that the clinical discriminating power of the Alpha-Bravo transition amounts to 189 ± 52 μm, which implies that, for example, where there is an abrasion of less than 150 μm, it will not be apparent clinically.[27] Phillips was misled by this in the first year of the study, and because of the improved wear resistance, this discriminating power will certainly be inadequate for the present generation of composites. In addition, with this qualitative method, good calibration and inter- and intra-examiner agreement among the evaluators is of great importance.[17]

MARGINAL EVALUATION ON MODELS

After determining that direct clinical wear evaluation is not adequate, it would seem logical to make use of impressions and models to circumvent problems of visibility, accessibility, etc. One way of doing this is to apply Ryge's criteria to a model evaluation, or an independent classification system.[28,29] In spite of the improved evaluation conditions, the discriminating capability will not in principle be much greater than in the clinical situation, because there is no mention of enlargement of the model. The situation can continually be recorded each year, however, so that two consecutive models can be compared with each other.[30]

In a comparison of three methods, Goldberg mentions alongside the USPHS criteria a so-called "ranking" method.[12] With this method, models of restorations made in the same year are ranked against each other according to the degree of wear. It is clear that this is a purely qualitative method.

The third method described by Goldberg was one in which models of restored teeth are compared with a standard calibration series of models, in which wear varies from "no wear" to "extensive wear". To make this standard series, the difference in height between the occlusal surface of the composite restoration and the cavosurface margin (= the height of the cavity wall exposed in time) was measured with a microscope for four die-stone models within part of the cavity margin. The calibration series of four values obtained in this way was then used to divide the restorations to be evaluated into the same number of categories.

Leinfelder's research group introduced some modifications to this concept.[31-35] Silicone impressions were made of a selection of models of restorations. For each tooth, sections were made in three places in the buccolingual direction, and the height of the exposed cavity wall was measured with a microscope on these sections. Six models for which this height amounted to a multiple of 100 μm were selected as reference values (0-500) μm), so that in the first instance six categories (0->500 μm) were obtained. In addition it should be possible to grade accurately between the reference values, in intervals of 25 μm.[26] The models were evaluated with the help of floodlighting, so that by shadowing, the loss of material on the cavity wall was clearly displayed. A magnifying glass was also used.

A similar evaluation method is that of Moffa and Lugassy (ML method).[36] As a standard reference series, solid cylinders were used where wear mechanically was simulated locally on the surface of one end. The successive measured values differed from each other by 25 μm, which provides a more precise scale division than Leinfelder's method. In addition, the mechanically produced induration has a standard form. This acts to the benefit of the eventual evaluation.

The evaluation of models is certainly simpler and more precise than a clinical evaluation, but the methods described above are sensitive to errors in evaluation by the researchers.[37,38] A good calibration is of great importance. As Eick quotes, these are as yet not quantitative methods, but good qualitative ones.[39] Localized wear is not measured; just as in clinical evaluation; only changes in the cavity margin are determined.[3]

HEIGHT OF THE EXPOSED CAVITY WALL

In order to determine the wear of restorations, it is possible to conduct measurement of the heights of the exposed cavity walls individually for every model. Jørgensen followed this principle and made the measurements on stone casts of restored teeth with the aid of a stereo microscope.[40,41] The height of the cavity wall, or the wall exposed in time, was measured at four points of the margin of molars with Class I cavities, and always at the base of the occlusal incline of the cusps. It should be possible to make six measurements, namely by the addition of a measurement at the mesial and distal ridge.[42] In order to achieve an optimal result, the models were positioned under the microscope in such a way that the cavity wall to be measured stood perpendicular to the optical axis of the objective.

Knudsen *et al* made measurements in the same locations with the same equipment.[43] In place of measuring the height of exposed cavity wall, the marginal excess of the restoration material on the unprepared portion of the enamel at the cavity margin was measured. For this purpose, the model was tilted so that the optical axis of the microscope was tangential to the occlusal enamel of the cavity margin, to allow determination of the thickness of the composite excess.

Wear is thus only determined on the margin of the restorations at a few points, difficult to reproduce, so that an incomplete picture is obtained. Positioning of the models under the microscope can cause problems. With the method of Knudson *et al* measurements cannot be made if, after wear of the composite, the level of the cavity margin is equal to that of the cavity wall; the excess is then lost. The wear measured may be more than physiological, however, since where there is an excess, a restoration with a high spot can result; in this way, the occlusion on the spot produces increased wear.

VOLUMETRIC ASSESSMENT OF IMPRESSIONS

In the above studies, impressions were only used as media for evaluation. The idea of the impression itself as the object of evaluation was applied by Handelman *et al* in the measurement of the volume of sealants *in vivo*.[44] The method was as follows: Impressions of the pre- and postoperative situations were made and poured in epoxy resin die materials. A coping was made on the model of the sealed tooth. Thereafter thin liquid impression material was applied to the coping, and the model of the preoperative situation (without sealant) was now placed in the coping, allowing the coping to make contact with all the unchanged parts of the model. In this situation, the impression material took on the volume of the sealant and the mass could be easily determined. The coping was also replaced on postwear models of the same tooth, and the space that was produced as a result of wear of the sealants was recorded by the impression material.

Dennison *et al* and also Van Groeningen *et al*, used this technique for wear measurement of posterior restorations.[45,46] Urquiola applied a modified version.[47] A silicone impression was taken from a stone model of the tooth just after restoration (baseline). This impression was placed on models of the tooth acquired later, and Hg was enclosed. The mercury was weighed and gave a measure of the volume loss of the restoration.

Hendriks introduced a further modification by carrying out the above principle not *in vitro* but *in vivo*.[48] For this purpose, a coping was made on a baseline model, and using this, impressions were made directly after restoration and during subsequent recalls. In places not subject to wear, in this case enamel, the coping makes contact with the tooth, and where wear appears, in this case composite, the impression material takes the place of the material which has been lost.

The method is simple and inexpensive. The technique, also described by Vrijhoef *et al*, can be used directly in the mouth.[49] No distinction can be made, however, between strongly and less strongly worn surfaces: the occlusion points (Occlusion Contact Area, OCA) and contact-free surfaces (Contact Free Area, CFA). In addition, because of the small quantity of impression material, weighing it is subject to relatively large variations. Finally, exact replacement of the coping can be made more difficult by wear of the enamel or the presence of debris.

PROFILOMETRY, ARTIFICIAL REFERENCE

A method by which a distinction can be made between occlusion points and contact-free surfaces of the restoration is described by Meier *et al*.[50-53] Here, surface profiles are made of copper-plated dies of restored teeth with the aid of a modified surface roughness tester. This is a horizontal "feeler" arm with a stylus at its end, which is movable in a vertical direction. The arm can be moved horizontally at a known speed, while the vertical deflection of the stylus is recorded (contact scanning). The profilometer is connected to an X-Y-recorder, which reproduces the surface profiles enlarged. The sections obtained in this way can be superimposed during recording of the same profile.

Accurate repositioning is of importance here, in order that surface profiles can be made in identical positions for every tooth over the course of time. Initially the cusp tops were ground so that a reference surface was formed running parallel to the occlusal plane; vertical adjustment of the models was guided by this surface.[50,51] Later, unground cusps were used for this purpose.[52,53] The horizontal site was determined by two or three reference pits prepared in the enamel, which could be read off from the model with a stereo microscope.

Two surface profiles of each tooth were made: one on the site of an OCA, and one on a CFA. Superimposition of the curves then directly yielded a vertical measurement for wear of the restoration on the spot.

Hirt *et al* modified the method.[54] Reference pits were prepared in the enamel, so that during profilometry of the occlusal plane, one reference point determined the starting point of a scan line and another the end. Two scan profiles were thus produced, one over an OCA and one over a CFA, both trajectories determined by two pairs of reference points.

An exact repositioning of the models does not appear to be necessary with Hirt's method, but tilting of a model gives a profile of a part of the occlusal plane that will lie next to the original profile. In addition, as with the other forms of this profilometric technique, measurements are made at a few sites, so that changes in the surface of adjacent parts are not evaluated. There is also an ethical difficulty concerning the acceptability of grinding sound enamel in the interests of research. Finally, selection of the measurement points, the OCAs and CFAs taken from the mouth, is arbitrary.

SECTION MEASUREMENT

A method that has the same theoretical background as the methods described above, in which profiles were superimposed, is the technique applied by Bodkin *et al*.[55] This technique is carried out by making a coping on the first model. The coping serves as a relocation jig for following models, so that buccolingual sections of the models can be cut in identical positions in a so-called "Isomet thin sectioning machine". Using a photographic enlargement of 100 x, the successive surface profiles of a section are superimposed, and in this way a measure of the wear is obtained that can be directly read off.

A problem with this method is relocation. When positioning the model in the coping, a correct placement can be made impossible by pollution or distortion of model or coping. Additionally, surface changes that cannot be reproduced may occur during cutting.

COORDINATE MEASURING DEVICE, CONTACT SCANNING

Roulet used a coordinate measuring device.[14] A model of a tooth was placed on a working stage driven by steppermotors. A stylus with a radius of 15 μm fixed the Z-coordinate by contact with the surface. The X- and Y-coordinates were calculated from the movement of the steppermotors. Compared with the profilometric method of Meier, the horizontal movement thus takes place here by displacement of the object rather than of the stylus.[50] A measurement is carried out every 100 μm and stored in the attached computer, and in this way numerous profiles of a restoration are produced. In total, the surface is mapped by 3000 up to 5000 points.

Orthodontic brackets with reference points, fitted to the teeth buccally and lingually, are used as references for this technique. The reference points can be read off with a microscope during placement of the models under the scanner. After an initial adjustment, the computer will improve on it by interaction between the measuring stylus and the steppermotors.

With the relocation method, the X-Y-coordinates of every point of measurement on every model can be recovered, and the vertical displacement of the surface can be read off virtually directly. To eliminate a small error in vertical relocation (for example rotation of the model), the Z-values of the reference points are converted to an adjusted reference plane. Software is responsible for the determination of the places with the maximum wear, and for the calculation of this.

In order to follow a patient over a longer period, the nonfunctional brackets remain *in situ*. The hindrance to oral hygiene thus caused can have consequences for the enamel and gingival tissues, while the aesthetics can create problems in the study of premolars. The method requires intensive labor, so that it is also difficult to evaluate large numbers of teeth.

A very simple form indeed of this technique is the method applied by Dogon *et al.*[56,57] During a study in which composite restorations on monkeys were evaluated, the wear was evaluated *in vivo* by use of a polymer coping, in which vertically movable pins could be positioned on the occlusal plane. In this way wear could be determined at locations selected in advance; measurement was made on the basis of the displacement of the top of each pin relative to the upper edge of the coping. The drawbacks of this method are the limited information that is obtained about the occlusal plane as a whole, and exact repositioning of the coping can give difficulties after the passage of time. The method is nevertheless inexpensive and simple to conduct.

A research group from the Johnson & Johnson factory also made use of a contact scanning method.[58,59] According to the authors, successive models were accurately placed under a 3-axis micrometer. Scanning with this apparatus takes place in a manner similar to that of Roulet. The writers do not mention, however, an interactive computer program that can eliminate small deviations in the relocation directly or indirectly. The relocation technique is also not described.

MEASURING MICROSCOPE

In 1983, Lambrechts presented a method in which use was made of a device known as a measuring microscope.[8,60] This is an optical microscope in which the vertical adjustment of the objective is easily readable and can be accurately determined because of the slight depth of field (1-2 μm).

Accurate measurement demands exact repositioning

Depending on wear, the microscope would be out of focus; the change on the Z-axis needed to bring the object into focus is a measure for the wear that has occurred.

of the objects. In order to determine the position of the baseline models and to be able to reconstruct that of following replicas, four shallow reference pits were prepared in the enamel. These pits were located on nonoccluding points in the occlusal plane.

By means of a silicone relocation jig made on the first model, the models could be positioned under the microscope virtually identically. One attrition point (OCA) and one abrasion point (CFA) were determined on the baseline model, after which the X-, Y- , Z-coordinates of these two points and of the four reference points were established by placement under the microscope, and stored in the attached computer.

Next the coordinates of the reference points, which together formed a reference plane, were fixed on the postwear models. Inaccuracies in repositioning in the relocation jig gave variations in the coordinates of the reference plane of the baseline model in comparison with a postwear model. By application of a mathematical matrix procedure, the reference points could, however, be made equal to each other. The same matrix procedure could now be applied to the coordinates of the two measurement points determined on the baseline model, and the coordinates calculated in this way could be adjusted in the microscope for the postwear model. Depending upon wear, the microscope would be out of focus and the change on the Z-axis needed to bring the object into focus is a measure of the wear that has occurred.

As in the case of profilometry with reference, the ethical aspect plays a role here, since sound enamel is ground for the benefit of research. During the replica method the reference points must be very accurately replicated; if not, errors that cannot be reproduced will arise. During focusing, where there is a small deviation in the adjustment, the eye will still be capable of forming a sharp image by means of accommodation; the plane is then not identically determined. In addition, because of the spot measurements, this method, as with that of Roulet, is very strenuous.

COORDINATE MEASURING MACHINE, NONCONTACT MEASUREMENT

Mettler *et al* chose a contact-free measurement for the purposes of wear research, with the use of an optical coordinate measuring machine.[61] This is a stereo measuring microscope in which the vertical location of a measurement point is set by the movement of the objectives, so that two crosses in the objectives can be brought to cover each other. The horizontal coordinates are set with the movable working stage.

The vertical location of a point is set by the movement of the objectives, so that two crosses can be brought to cover each other.

In order to avoid grinding the enamel when fixing the reference, the cusp tops were used as reference points for the measurements. In casts of the lower dental arch the top of a buccal cusp of the molar to be measured and a top of the buccal cusps of two contralaterally situated teeth formed a reference plane; possible vertical displacement of this plane through abrasion of the reference points was corrected by measurement of the height of a lingual cusp of the molar to be studied in terms of this plane.

Taking the top of the buccal cusp of the tooth to be studied as the origin of an axial cross, a grating was projected on the model under the measuring machine, in such a way that the X-axis ran through one of the other two reference points. By doing this, the X-Y-coordinates of the points to be measured could be determined and the Z-coordinates read off on the baseline model.

Since exact repositioning of the reference points under the measuring machine was not possible, despite the use of a working stage adjustable in several directions, the reference points of the baseline and postwear model were compared with each other by means of a matrix procedure (transponation). The X-Y-values of the measurement points could then be calculated with the same matrix and the measuring machine could be adjusted accordingly. The Z-values of the measurement mined with the measuring machine, and compared with the original Z-values by means of the reversed matrix procedure.

A problem with this technique is the definition of the reference plane. Selection of the highest point of a cuspal top can lead to inaccuracies, both in the horizontal and vertical directions. The cusp tops are worn away by one means or another, as a result of which the reference plane can both translate and rotate (where wear is unbalanced). Compensation for this by making use of the lingual cusp is then also inadequate.[62] In addition, displacement of teeth can disturb the reference. The method is strenuous when measuring large numbers of models.

PHOTOGRAMMETRY

In order to obtain on paper a three-dimensional model of the dentition and surrounding tissues, Gruner *et al* applied the measurement technique of photogrammetry, used in cartography.[63] The principle of photogrammetry, or rather stereo photogrammetry, is based upon the function of the human eye. The distance between the left and right eye gives two images when looking at an object, the optical axes of which form an angle with each other. If two photographs of an object are now taken from two viewpoints, such that the angle obtained between the optical axes matches that of the eyes, and the left eye sees the left photo while the right eye sees the right one, this corresponds with natural vision. Because of the difference in the optical axis in the two photographs, the object appears to be displaced from the background when the photos are compared with each other. This shift is known as parallactic displacement.

If the two images are projected at an angle equal to the angle of exposure, a three-dimensional picture can be created in a modified stereo viewer, stereo plotter or digitizer. The photos obtained form what is known as a stereopair; distances can be measured and a map with contour lines produced.[64-66] Requirements for the exposure technique are an equal object distance for the photos (= flight altitude in aerial cartography), exact determination of the object distance, and the use of metric or semimetric cameras.

Eick *et al* applied this technique for *in vivo* wear measurement, called the Buffalo system.[39,66,67] Two cameras were attached firmly to a frame at some distance from each other, and both were pointed toward mirrors fixed to the frame.

An individual bite splint was also secured to the frame. The restoration to be studied could be photographed in the mirrors through a hole located in the bite splint. In this way a stereopair could be obtained. Reference points were situated on the edge of the hole in the bite splint.

The great advantage of this technique is that the data acquisition takes place *in vivo*, so that measurement inaccuracies are not produced through errors in the impression or casting procedure. A correct fit of the bite splint, however, is essential. Certainly in longitudinal studies an imperfect relocation can come about through dimensional change of the plate on the one hand, or through changes in the dental arch on the other. Accurate determination of the distance (flight height) is then difficult.

To determine height differences between points in a landscape which is uniform in terms of color, a cartographer looks for points of contrast (such as stones). For this purpose, Ogle sprayed the models *in vitro* with a "stipple" spray.[66] The authors are not aware that Eick uses such a spray, and hence the lack of contrast in the tooth could cause difficulty in the reading of the measurement points on the photos.

MOIRÉ TOPOGRAPHY

In the seventies an optical technique for studying three-dimensional objects was applied in various fields of science, the moiré-fringe technique.[68-72] With this principle, a grating is placed over the object to be studied, having parallel lines, with the line spacing such that no diffraction phenomena are produced behind the grating. Grating and object are lit by a lamp, or preferably by a parallel beam of light, and observation of the object takes place from a distance through the grating, hence from the same side as the light source. Because of interference by the shadow of the grating upon the object and its image, as seen from the observation point, a characteristic pattern of stripes is produced (comparable with the image familiar from printing technology of two gratings covering each other). The pattern of stripes gives the contour lines of the object. This striping only reflects exact surface contours, if the camera and the light source are at the same distance from the grating.[73] The deviation of the parallelism from the concentric contour lines is a measure of the difference in level. The surface contours can be determined photographically.

Ozaki *et al* employed this principle in their morphological study of molars; *in vivo* wear research with the aid of this technique was carried out by, among others, Meint *et al.*[74,75] They made use of models that were positioned in front of the exposure apparatus by means of a relocation jig. With successive models, the areas not subject to wear could be directly determined; the contour lines were unchanged. Surface profiles were produced with a calculation program from those contour lines that had changed, and by superimposition of the successive profiles of a section, the wear could be determined.

This method differs in execution from the standard moiré fringe technique, in that lighting is provided from two light sources instead of one. This gives reduced shadowing and avoids reflection from the grating. The angle between the light sources is 90 degrees, and the camera is situated on the central vertical line of the grating, between the light sources.

As with other techniques that make use of a relocation jig, correct replacement of the models is essential, and if errors occur here (dust or distortion of the jig), the results are not comparable.

LASER INTERFEROMETRY

Techniques which are founded upon interferometry, but which make use of coherent light, are the laser dual source contouring technique and the moiré contouring technique applied by Jongsma *et al.*[7,76-79]

Laser light (laser = light amplification by stimulated emission of radiation) is monochromatic (single wavelength), coherent (single frequency) and parallel, and hence the techniques mentioned make use of the coherence. Two diverging light beams meeting one another, originating from the same laser source, can create an interference pattern that is comparable with the pattern in the interference tests of Young (in 1807) and Fresnel (in 1823). With two beams from a normal light source, interference will indeed be produced when they meet; but no clear pattern will emerge, due to the presence of different frequencies.

With the laser dual source contouring technique, a laser beam is separated through a prism into two divergent beams. The two beams meet each other again at a distance of 50-100 cm from the prism and the object is situated in the interference zone, placed obliquely in the beam. The optical axis of an erected camera stands perpendicular to the surface of the object and the interference pattern of the beams upon the object can thus be determined.

Measurements were made on impressions of teeth, which were positioned with a relocation jig in the arrangement. The wear was expressed in volume units. The distance between the contour lines amounted to 100 to 200 μm.

Jongsma *et al* also split a laser beam with the aid of a prism.[78,79] An arrangement with mirrors projected the beams from two directions onto the object, each with a grating placed in between, so that a moiré projection was formed. The interference pattern consisted of light (in-phase) and less light (out-of-phase) lines, and was recorded photographically. In comparison with conventional moire techniques, gratings with minute fine rulings were used. Contrast enhancement was necessary because of the diffraction phenomena that then appeared. This was done by lighting the film negative, with the interference pattern, with a parallel monochromatic light source, and a filter then eliminated the parts that were out-of-phase; a black-and-white image was obtained. In a further study, a television system was applied. With this real-time recording, filtering was achieved by the application of an electronic band pass filter that blocked the out-of-phase parts.

For the purposes of accurate repositioning of the objects, a rigid working stage was developed with six degrees of freedom. Repositioning took place on the basis of three reference points ground into the enamel. With this method, use was made of impressions that were coated with a fluorescent film to enable the ideal reflection to be achieved during recording. As with the other moiré methods, software was developed to calculate the wear.

The above techniques are clearly less simple in execution than the conventional moiré techniques. The relocation jig for the first technique can create repositioning problems, while question marks on ethical grounds can be placed beside the grinding of the enamel in the second. With the laser dual source contouring, the interference pattern is projected obliquely onto the object. Because of this, however, the distance between the contour lines will differ between areas farther away and those situated closer by. A conversion program thus seems to be necessary as an extra instrument to eliminate this difference.

PROFILOMETRY, NATURAL REFERENCE

A method that connects with the profilometric methods mentioned above is that described by DeLong *et al.*[80-83] From an extensometer, the stylus registers the vertical orientation, while horizontal orientation takes place using a working stage driven by steppermotors. The contact pressure of the stylus is controlled under the working stage by a servohydraulic machine.[84] In this way different profiles of the surface of an object can be determined, in this case epoxy models of teeth.

The data are directly stored in the attached computer and a three-dimensional graphic display, known as a wire model, can be obtained on a visual display screen. Given that no reference points are introduced to objects *in vivo*, the step now to be taken is considered to be essential. In order to compare the contours of pre- and postwear models with one another, the two contour models were tested for "exactness of fit", which means that the unchanged contour areas were set equal to each other (including by extrapolation). Checking takes place on the screen by overprojection of the two contour models. Areas of wear can now easily be distinguished and these can be indicated by the operator using a screen cursor, following which a computer program can calculate the change in volume. Image processing also makes it possible to determine the reduction in height at indicated places.[82]

McDowell *et al* used the same principle for the determination of profiles as described above.[85] A three-coordinate measuring machine was applied here, however, for data acquisition. Not the working stage, but the stylus is moved horizontally. When scanning a profile, a measurement is made every 10 μm, so that a dotted curve is produced.

The advantages of these methods are evident. For repositioning, it is not necessary to grind the enamel or to make use of a relocation jig. It is also not necessary to be restricted to parts of the surface defined in advance for wear research; the places subject to wear can be determined afterwards. Only the data acquisition can cause inaccuracies. One example to consider is the geometry of the stylus tip. When a steep cuspal incline or an exposed, steep cavity wall is traced, the side of the tip rather than the tip-end will make contact with the surface. The extremity of the tip is the measuring point, so that where contact is made with the side the measurement is not accurate; in this case, excessively low values will be given.

SCANNING ELECTRON MICROSCOPY

Scanning electron microscopy (SEM) has been used increasingly in recent years in the surface analysis of materials.[86] Abell *et al* studied the surface of an old composite restoration with the aid of SEM equipment.[87,88] The wear was calculated from the extent to which a large filler particle (ca 50 μm) had come away from the surrounding matrix, as a result of wear.

Scanning electron microscopy has been used increasingly in recent years in the surface analysis of materials.

The evaluation is clearly very local. It is necessary that with repeated measurements the right particle is evaluated at the same optical angle and that, due to wear of a few tenths of a micrometer per day, the models should be made at short time intervals of a few weeks.[87]

The latter is certainly impracticable in a large-scale clinical study. In addition, for current composites with their smaller filler particles, the method will be difficult to apply, while wear (through loss) of the particles themselves will not be registered.

Russ *et al* reported on the application of SEM photogrammetry in the determination of wear of facial root surfaces of incisor teeth after polishing by the dentist.[89] Since the polished surface was relatively large (6 mm^2), use was made of a low 50 X enlargement and a horizontally movable object in order to obtain stereopairs. The method corresponds with aerial photogrammetry, on condition that now the object moves in place of the recording apparatus. Using a greater enlargement, Roberts *et al* made use of an object upon a tiltable working stage in order to obtain a difference between the optical axes.[90] The two different methods are also designated as the shift-only (translation) and the tilt-only method (rotation).[86]

Processing of the SEM stereo photos is carried out in the same way as for the "normal" stereo pairs with the aid of a stereo plotter. By calculation of numerous points, contour lines can be generated with an interval of 2.5 μm.[86] A clear contour map can then be made, in which reference points can be found in small grooves in the enamel.[89] Enamel wear can then erase, however, the reference points. Creation with software of a three-dimensional wire model and an "exactness of fit" program may be more appropriate.

Problems with the SEM photogrammetry were reported by Roberts *et al.*[90] The method is strenuous and time-consuming, both as regards model manufacture (all models must be metal coated, impressions cannot be used in the apparatus) and processing of the photos. Because of the enlargement and the necessary overlap of the photos, numerous exposures are needed to map a surface of 1 cm^2. With the "tilt-only" method, the precision of the tilting stage is of great importance; a small deviation in the angle can have a large distorting effect upon the results. With the "shift-only" method, this distortion can appear with a small deviation in the parallelism of the movement of the object.

Another SEM application is described by a research group from Leeds.[91,92] It is a sort of SEM apparatus in which the electronbeam is not controlled by scancoils, but it has a fixed location in space. Consequently the instrument requires a less extensive elecromagnetical lens system. The profilometric principle is applied; with respect to the beam a working stage is moved by the operator and by collecting the electrons reflected from the surface of the object (backscattered β particles) a broken surface profile is formed. In addition, a ^{147}Pm source is used instead of a tungsten filament. This will probably be used because of the energetically stable electron emission, so as to avoid too much noise in the detection.

The method has not been described as a tool in *in vivo* research. Nevertheless, it has been stated to use metal coated casts when measuring *in vivo* wear.[91] It is also stated that the type of change in surface profile determines the accuracy of the records. A flat surface will be adequately mapped, but the measurement of a complicated profile lacks accuracy.[92] The conversion of the electronic information into analogue data requires a great deal of mathematical skill. Finally there is no description of reference points whatsoever.

OPTICAL SCANNING

In 1989, DeLong *et al* presented a laser scanning method as an application in wear research.[93] A laser beam with a radius of approximately 3.5 μm was moved across the surface of a model (scanning), corresponding with contact measurement with a stylus. The occlusal morphology of the tooth could be recorded in profiles in an attached computer (three-dimensional wire model). The method of calculating the location of the laser point on the surface was not described.

The advantage of this method is that because of the small dimensions of the "measuring instrument", this technique will be more easily applicable in the scanning of occlusal surfaces with grooves and ridges, where the geometry of contact measurement styli can create problems. To determine the location of the laser point, use will probably be made of a "time of flight" technique, in which the distance to an object is determined by the time that the light requires to complete the trajectory, laser source to object to video camera. Phase differences between the emitted and reflected beams then ensure that interferometric principles of measurement can be applied, similar to the measurement

Seen in this light, wear research can form a part of clinical longitudinal research in the behavior of composite restorations in natural teeth in the posterior region.

of length with a Michelson interferometer.[94] The drawback of the method is the high cost of the necessary precision equipment.

DISCUSSION

The measurement of wear of restoration materials in general, and of posterior composites in particular, is the subject of considerable interest of various research groups. With the improvement of the material properties of the composite and the development of nondestructive research, an accompanying evolution of research in clinically functioning composite restorations took place. The justification for the performance of clinical research is expressed in a quotation such as that of Mjör, "No laboratory test can currently reflect the changes which occur *in vivo*."[95] Roulet proposed, "Since determination of the longevity of the restoration based on short-term results (e.g., six months or less) is the objective, the better the measuring precision and accuracy of such short-term tests are, the more accurate the prognosis will be.".[9] From these quotes, it can be concluded that the motivation still exists to seek refined methods of determining wear in the future.

Seen in this light, wear research can form a part of clinical longitudinal research in the behavior of composite restorations in natural teeth in the posterior region. In this way a distinction can be made from research in which use is made of denture teeth as holders of the restorations. The advantage of this latter research is that the evaluation of the worn restoration can take place outside the mouth, in the laboratory. Problems of comparability, however, can occur. The functioning of dentures is different in terms of occlusion and articulation than that of natural teeth although researchers differ in their opinions about this phenomenon.[42,96,97] The bonding of composite to porcelain also does not correspond with that to enamel.

Clinical evaluation in accordance with the USPHS criteria is particularly suitable for application in longitudinal clinical research. The discriminating capacity is insufficient, however, for present-day composites. Additionally, wear is mainly determined at the margin of the restoration.

The USPHS evaluation upon models, margin evaluation with standard calibration series and measurement of the cavity wall height also share the disadvantages of local evaluation at the margin. Of these three, Leinfelder's method is the easiest to fit in with research, with the restriction that it involves no true measurement, but a division into levels of wear.

Methods whereby the worn part of the restorations is taken up by a medium during evaluation express the wear in units of volume. With these techniques, no distinction can be made between OCAs and CFAs, while repositioning of the coping as an "impression tray" can lead to inaccuracies (enamel wear in the impression, debris). Repositioning can also cause problems with other methods in which copings or relocation jigs are used (*in vivo* or *in vitro*). Where cusp tops are employed as references, the abrasion of the enamel can be responsible for changing the reference plane.

In large-scale longitudinal research, methods in which reference points that are introduced into or onto the enamel appear unsuitable because of ethical considerations. It is probable, however, that the techniques that are used for measurement (profilometry, three-dimensional scanning, measuring microscope, moiré contouring according to Jongsma) can be applied where the choice of references changes.

With photogrammetric techniques (either normal photographs or SEM exposures), it is possible to do away with the introduction of reference points. Because of the enlargement, SEM should be capable of being very accurate. A limiting factor here is the reconstruction of the large number of photos needed and the associated accuracy with which movements of the working stage can be determined. Roberts concluded from the labor intensive aspect that the method is too complex for wear measurement.[90] Normal stereo photogrammetry according to the Eick method has the disadvantage of the use of a reference splint, which can be difficult to reposition.

Where wear measurement is done as part of longitudinal research, the following considerations can play a role in making a choice of measurement technique:

- ☐ The additional information that is obtained by application of advanced instruments must be viewed in the light of a time and cost analysis.[12] Given the above, however, a present-day wear measurement will always have to rely on more than human observation.
- ☐ Direct computer-aided 3-D reconstruction of the restoration in the mouth should be able to give an advantage over the use of impressions and models.

With a replica technique, dimensional variations and processing faults of the materials can be the source of nonreproducible errors, while casting voids, furthermore, are often unavoidable. The present nondestructive data acquisition techniques for use in the mouth are, however, in general, in the developmental phase and are certainly not yet applicable on a large scale. These include stereo photogrammetry, laser interferometry and structured light projection (that is to say, the projection of a grating on a transparency onto an object, and recording of the distortion of the grating with the aid of a photographic or video camera).[94,98-102]

The above techniques must be seen as a part of the total CAD/CAM development in restorative treatment in dentistry, which is to say the mapping of the prepared tooth, and the automated production of a restoration. Techniques such as those cited are thus not specially aimed at dental wear research. Further noncontact data acquisition techniques which have been reported and are applicable in the mouth, include contouring holographic interferometry (in which a contour image is obtained by the interference of two laser beams with a small variation in wave length between them), rasterstereography or the static projection of structured light (see "structured light"), and dynamic projection of structured light (that is to say the projection of a moving chink of light over the surface of the object, or a laser chink or chink of noncoherent light, and registration of the distortion on photo or video, a scanning technique).[103-112] With contact measurement, as with profilometry, the apparatus is at present still too large for use in the mouth.

☐ At the moment a replica thus appears to be unavoidable as the object of measurement. The problem of the errors arising can be limited by the use of individual impression trays and standardized procedures. By the use of a polyvinyl siloxane impression material and epoxy resin as the modelling material, variations in the procedure are minimal.[113] The error is then limited within a study. The advantage of models, but also of three-dimensional images produced by software, is that remeasurement of the results after a longer period is possible. With the use of impressions alone, this is not the case because of dimensional changes over the long term.

☐ A fourth consideration that comes to the fore is the choice of the reference and the condition holds that no changes to the tooth or to the restoration can be made in order to obtain fixed reference points. The image processing described by DeLong seems to be usable as a good alternative here.[81] Reference can then be made to the free smooth, unrestored surfaces of the tooth, where changes will hardly occur over the coarse of time (except for wear by, amongst other causes, the toothbrush). Hard- and software is necessary to be able to apply an "exactness of fit" program, and thus to be able to superimpose wire models.

A laser scan technique appears to have great potential.

☐ Finally, the data acquisition method to be applied in the laboratory will play a role. The accuracy of the measurement techniques described is sufficient, in general, to detect differences in height of 10 μm. The error of the whole procedure is generally, however, the problem, and as mentioned, this is not indicated by authors in a constant way. As regards geometry, contact measurement requires less extensive software in comparison with noncontact measurement. The software will on the other hand have to be elaborated specifically for contact scanning; measurements with the side of a stylus point will need to be able to be converted. The measurements of a stylus can be a limitation upon access to fissures. As regards noncontact measurement techniques, the methods described that are usable for the generation of contour lines can be extended with the above CAD/CAM techniques and with those applied in medical research.

Photogrammetric methods are more labor intensive than laser (scan) techniques, interferometry or work with structured light. Shadowing is the greatest obstacle that can distort the measurements with most of the optical techniques. By tilting the models, this problem can be overcome, in most cases.

In longitudinal clinical research, the desired accuracy and alongside it, the simplicity of the wear measurement method, are important considerations in the choice of a technique. Where large numbers of teeth are concerned, the work that must be expended to carry out the method is additionally of importance. As may be evident, various data acquisition techniques are suitable for application in this type of measurement research. Given the simplicity and the accuracy that can be expected, a laser scan technique, in which a tooth is mapped by means of a light chink moved over the surface, appears to have great potential in clinical research.

REFERENCES

1. Bowen, R.L.: Dental filling material comprising vinyl silane treated fused silica and a binder consisting of the reaction product of bisphenol and glycidil acrylate. U.S. Patent 3.066.112, 1962.
2. Buonocore, M.G.: A simple method of increasing the adhesion of acryl filling materials to enamel surfaces. J Dent Res, 34:849-853, December 1955.
3. Leinfelder, K.F.: Evaluation of clinical wear of posterior composite resins. In: *Posterior composite resin dental restorative materials*. Vanherle, G. and Smith, D.C. eds. The Netherlands: P. Szulc, 501-509, 1985.
4. McCabe, J.F.: In vitro wear testing of composite resins. In: *Posterior composite resin dental restorative materials*. Vanherle, G. and Smith, D.C. eds. The Netherlands: P. Szulc, 319-330, 1985.
5. McLean, J.W.: Limitations of posterior composite resins and extending their use with glass ionomer cements. Quint Int, 18:517-529, August 1987.
6. Swift, Jr., E.J.: Wear of composite resins in permanent posterior teeth. J Am Dent Assoc, 115:584-588, October 1987.
7. Atkinson, J.T.; Groves, D.; Lalor, M.J. *et al*: The measurement of wear in dental restorations using laser dual-source contouring. Wear, 76:91-104, 1982.
8. Lambrechts, P.: Basic properties of dental composites and their impact on clinical performance. Leuven, Belgium: Katholieke Universiteit, 1983. Thesis.
9. Roulet, J.F.: A materials scientist's view: assessment of wear and marginal integrity. Quint Int, 18:543-552, August 1987.
10. Binon, P.; Morris, C.; Garman, T. *et al*: Clinical evaluation of an experimental composite in Class II restorations. J Dent Res, 55:B191, IADR abstr 519, 1976.
11. Bausch, J.R.: Tandheelkindige composieten II. Amsterdam, The Netherlands: Universiteit van Amsterdam, 1982. Thesis.
12. Goldberg, A.J.; Rydinge, E.; Santucci, E.A. *et al*: Clinical evaluation methods for posterior composite restorations. J Dent Res, 63:1387-1391, December 1984.
13. de Gee, A.J.; Davidson, C.L.; Frijn, M.J.: An in vitro study into the conditions causing wear of posterior restoratives. J Dent Res, 64:370, IADR abstr 1762, 1985.
14. Roulet, J.F.: Degradation of dental polymers. Basel-New York: Karger, 1987.
15. Cvar, J.F. and Ryge, G.: Criteria for the clinical evaluation of dental restorative materials. San Francisco: National Institute of Health, USPHS Publication 790-244, 1971.
16. Ryge, G. and Snyder, M.: Evaluating the clinical quality of restorations. J Am Dent Assoc, 87:369-377, 1973.
17. Ryge, G.: Clinical criteria. Int Dent J, 30:347-358, 1980.
18. Gibson, G.B.; Richardson, A.S.; Patton, R.E. *et al*: A clinical evaluation of occlusal composite and amalgam restorations: one- and two-year results. J Am Dent Assoc, 104:335-337, March 1982.
19. Derkson, G.D.; Richardson, A.S.; Waldman, R.: Clinical evaluation of composite resin and amalgam posterior restorations: three year results. J Can Dent Assoc, 50:478-480, June 1984.

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20. Phillips, R.W.; Avery, D.R.; Mekra, R. *et al*: One-year observations on a composite resin for Class II restorations. J Prosthet Dent, 26:68-77, July 1971.
21. Phillips, R.W.; Avery, D.R.; Mekra, R. *et al*: Observations on a composite resin for Class II restorations: two-year report. J Prosthet Dent, 28:164-169, August 1972.
22. Phillips, R.W.; Avery, D.R.; Mekra, R. *et al*: Observations on a composite resin for Class II restorations: three-year report. J Prosthet Dent, 30:891-897, December 1973.
23. Osborne, J.W.; Gale, E.N.; Ferguson, G.W.: One-year and two-year clinical evaluation of a composite resin vs amalgam. J Prosthet Dent, 30:795-800, November 1973.
24. Leinfelder, K.F.; Sluder, T.B.; Sockwell, C.L. *et al*: Clinical evaluation of a composite resin vs amalgam. J Prosthet Dent, 30:795-800, November 1973.
25. Nelson, G.V.; Osborne, J.W.; Gale, E.N. *et al*: A three-year clinical evaluation of composite resin and a high copper amalgam in posterior primary teeth. J Dent Child, 47:414-418, November-December 1980.
26. Leinfelder, K.F.: Current developments in posterior composite resins. Adv Dent Res, 2:115-121, August 1988.
27. Taylor, D.F.; Sturdevant, J.R.; Wilder, A.D. *et al*: Comparison of direct and indirect methods for composite wear analysis. J Dent Res, 66:182, IADR abstr 607, 1987.
28. Bishop, B.: 1 year review Heliomolar restorations - preliminary report. Schaan, Liechtenstein: Vivadent Ind., June 1985.
29. McComb, D.: Evaluation of clinical wear of posterior composite resins. In: *Posterior composite resin dental restorative materials*. Vanherle, G. and Smith, D.C. eds. The Netherlands: P. Szulc, 1985, pp 511-517
30. Santucci, E.A.; Racz, W.B.; Norman, R.D.: A new method for evaluating posterior composite restorations. J Dent Res, 58:328A, IADR abstr 945, 1979.
31. Wilder, A.D.; May, K.N.; Leinfelder, K.F.: Klinische 5- Jahres-Studie von UV-lichtgehartenden composites im Seitenzahnbereich. Phillip J, 2:259-263, September 1985.
32. Leinfelder, K.F.; Taylor, D.F.; Barkmeier, W.W. *et al*: Quantitative wear measurement of posterior composite resins. Dent Mater, 2:198-201, 1986.
33. Heymann, H.O.; Wilder, Jr., A.D.; May, Jr., K.N. *et al*: Two-year clinical study of composite resins in posterior teeth. Dent Mater, 2:37-41, 1986.
34. Sturdevant, J.R.; Lundeen, T.F.; Sluder, Jr., T.B. *et al*: Three-year study of two light-cured posterior composite resins. Dent Mater, 2:263-268, 1986.
35. Vann, Jr., W.F.; Barkmeijer, W.W.; Mahler, D.B.: Assessing composite resin wear in primary molars; four-year findings. J Dent Res, 67:876-879, May 1988.
36. Leinfelder, K.F.: Evaluation of criteria used for assessing the clinical performance of composite resins in posterior teeth. Quint Int, 18:531-536, August 1987.
37. Taylor, D.F.; Turnbull, C.D.; Leinfelder, K.F.: Comparative evaluation of casts for the measurement of composite wear. J Dent Res, 63:293, IADR abstr 1104, 1984.
38. Sturdevant, J.R.; Lundeen, T.F.; Sluder, Jr., T.B. *et al*: Five-year study of two light-cured posterior composite resins. Dent Mater, 4:105-110, 1988.
39. Eick, J.D.: In vivo wear measurement of composite resins. In: *Posterior composite resin dental restorative materials*. Vanherle, G. and Smith, D.C. eds. The Netherlands: P. Szulc, 1985, pp 351-364
40. Jørgensen, K.D.; Horsted, P.; Janum, O. *et al*: Abrasion of Class I restorative resins. Scand J Dent Res, 87:140-145, 1979.
41. Hørsted, P. and Borup, J.: In vivo abrasion of Profile and Adaptic composite resins. Scand J Dent Res, 92:249-252, 1984.
42. Jørgensen, K.D. and Asmussen, E.: Occlusal abrasion of a composite restorative resin with ultra-fine filler — an initial study. Quint Int, 9:73-78, report 1646, June 1978.

43. Knudsen, M.B. and Jørgensen, K.D.: Abrasion of microfill restorative resins in Class I cavities. Scand J Dent Res, 91:159-161, 1983.
44. Handelman, S.L.; Jensen, O.E.; Pameijer, C.H.: Quantitative assessment of sealant wear in vivo. J Prosthet Dent, 40:531-533, November 1978.
45 Dennison, J.B.; Powers, J.M.; Charbeneau, G.T.: Measurement of in vivo wear on posterior composite restorations. J Dent Res, 59:318, IADR abstr 202, 1980.
46. van Groeningen, G. and Arends, J.: In vivo-abrasion of composites: a quantitative investigation. Quint Int, 12:1101-1106, report 2039, October 1981.
47. Urquiola, N.J. and Charbeneau, G.T.: Quantitative evaluation of clinical wear of posterior composite resin restorations. J Dent Res, 60:583, IADR abstr 1093, 1981.
48. Hendriks, F.H.J.: Posterior composite restorations. Nijmegen, The Netherlands: Katholieke Universiteit Nijmegen, 1985. Thesis.
49. Vrijhoef, M.M.A.; Letzel, H.; Hendriks, F.H.J.: A method to determine the loss of substance of dental restorations. J Oral Rehabil, 12:9-16, January 1985.
50. Meier, Ch.: Eine Methode zur Bestimmung der Verschleissfestigkeit von Füllungsmaterialien in Vivo. Zürich, Switzerland: Universität Zürich, 1977. Thesis.
51. Meier, Ch. and Lutz, F.: Verschleissmessungen in vivo an okklusalen Komposit- und Amalgamfüllungen. Dtsch Zahnärztl Z, 33:617-622, 1978.
52. Ameye, C.: Vergleichende in vivo-und in vitro- Untersuchungen von verschieden aufgebauten Kompositkonstruktionen. Tübingen, Germany: Universität Tübingen, 1982. Thesis.
53. Meier, D.; Fringeli, G.; Lutz, F.: Einjährige In-Vivo- Verschleissuntersuchungen eines Mikrofüllerkomposits im Seitenzahngebiet. Schweiz Mschr Zahnheilk, 92:1099-1108, December 1982.
54. Hirt, Th.; Lutz, F.; Roulet, J.F.: In vivo evaluation of occlusal wear of two experimental composites versus amalgam. J Oral Rehabil, 11:511-520, 1984.
55. Bodkin, J.L. and Nathanson, D.: Quantitative analysis of restorative material wear in vivo. J Dent Res, 61:302, IADR abstr 1117, 1982.
56. Dogon, I.L. and van Leeuwen, M.J.: Two year evaluation of posterior restorative materials using M. Fasicularis as the experimental model. J Dent Res, 62:253, IADR abstr 759, 1983.
57. Dogon, I.L.: Current status of posterior composite resins in North America. In: *Posterior composite resin dental restorative materials.* Vanherle, G. and Smith, D.C. eds. The Netherlands: P. Szulc, 1985, pp 163-171.
58. Potts, R.M.; Racz, W.B.; Farrington, A.P.: The quantitative measurement of wear of occlusal restorations in the clinical situation. J Dent Res, 55:B93, IADR abstr 128, 1976.
59. Santucci, E.A. and Racz, W.B.: One year evaluation of posterior restorations in a primate model. J Dent Res, 61:247, IADR abstr 618, 1982.
60. Lambrechts, P.; Vuylsteke, M.; Davidson, C.L.: Quantitative evaluation of the wear resistance of posterior dental restorations: a new three-dimensional measuring technique. J Dent, 12:252-267, 1984.
61. Mettler, P.; Friedrich, U.; Roulet, J.F.: Studie über die Abrasion von Amalgam und Komposits im Seitenzahnbereich - Schweiz Mschr Zahnheilk, 88:324-344, 1978.
62. Roulet, J.R.; Mettler, P.; Friedrich, U.: Studie über die Abrasion von Komposits im Seitenzahnbereich - Resultate nach 3 Jahren. Dtsch Zahnärztl Z, 35:493-497, 1980.
63. Gruner, H.; Zulquar-Nain, J.; Zander, H.A.: A short-range system for dental surgery. Photogrammetric Eng, 33:1240-1245, June 1967.
64. Bergström, J.: Photogrammetric registration of dental plaque accumulation in vivo. Acta Odontol Scand, 39:275-284, 1981.
65. Straka, L.; Kříž, V.; Štěpánek, B.: Die Fotogrammetrie in der Stomatologie. Stomatol DDR, 31:50-56, 1981.
66. Ogle, R.E. and Ortman, L.F.: Measuring wear of artificial teeth with stereophotography: Part I. J Prosthet Dent, 53:807-812, June 1985.
67. Eick, J.D.; Ortman, L.F.; Allen, T.B. *et al*: General clinical application of a stereo-camera system. J Dent Res, 52:219, IADR abstr 642, 1973.
68. Meadows, D.M.; Johnson, W.O.; Allen, J.B.: Generation of surface contours by moire patterns. Appl optics, 9:942-947, 1970.
69. Takasaki, H.: Moire topography. Appl Optics, 9:1467-1472, 1970.
70. Karara, H.M.: *Handbook of non-topographic photogrammetry.* 1st ed. U.S.A.: Everybodys Press (American Society of Photogrammetry), 1979.
71. Windischbauer, G.: Survey on applications of moire- techniques in medicine and biology. In: *Optics in biomedical sciences* von Bally, G. and Gressus, P. eds. (Proc. of the International Conference). Berlin: Springer Verlag, 244-249, 1982.
72. Lane III, H.B.: Photogrammetry in medicine. Photogram Eng Remote Sens, 49:1453-1456, October 1983.
73. Boone, P.M.: Optical methods to measure shape and size. Adv Dent Res, 1:27-38, October 1987.
74. Ozaki, T.; Kanazawa, E.; Sekikawa, M. *et al*: Three- dimensional measurements of the occlusal surfaces of the upper molars in Australian Aboriginals. Austr Dent J, 32:263-269, 1987.
75. Meint, R.; Rein, H.; Riethe, P.: Verschleissfestigkeitsmessungen mittels Moire-Topographie an okklusionstragenden Kompositfüllungen der Klasse I/II. Dtsch Zahnärztl Z, 39:110-113, 1984.
76. Atkinson, J.T.; Lalor, M.J.; Cantwell, J.B. *et al*: Comparative wear studies of dental amalgam using two novel techniques, laser fringe contouring and surfometry. In: *Transactions of the 11th International Biomaterials Symposium*, 3:78, 1979.
77. Williams, D.F.; Cunningham, J.; Lalor, M.J. *et al*: Laser techniques for the evaluation of wear in Class II restorations. J Oral Rehabil, 10:407-414, 1983.
78. Jongsma, F.H.M.; Lambrechts, P.; Vanherle, G.: Contouring of tooth imprints by means of a fluorescence technique adapted to a spatially filtered moire illumination. In: *SPIE Biostereometrics* '82, 361:76-80, 1983. Herron, R.E. ed.
79. Jongsma, F.H.M.; Janssen, H.L.M.M.; Lambrechts, P. *et al*: A different contour-mapping system for the measurement of wear in dental restorations. SPIE Biostereometrics '85, 602:85-90, 1985.
80. DeLong, R. and Douglas, W.H.: A methodology for the measurement of occlusal wear, using computer graphics. J Dent Res, 62:220, IADR abstr 456, 1983.
81. DeLong, R.; Pintado, M.; Douglas, W.H.: Measurement of change in surface contour by computer graphics. Dent Mater, 1:27-30, February 1985.
82. Pintado, M.R.; Conry, J.P.; Douglas, W.H.: Measurement of sealant volume in vivo using image-processing technology. Quint Int, 19:613-617, September 1988.
83. Conry, J.P.; Pintado, M.R.; Douglas, W.H.: Measurement of fissure sealant area by computer. Quint Int, 21:27-33, 1990.
84. DeLong, R. and Douglas, W.H.: Development of an artificial oral environment for the testing of dental restoratives: bi-axial force and movement control. J Dent Res, 62:32-36, January 1983.
85. McDowell, G.C.; Bloem, T.J.; Lang, B.R. *et al*: In vivo wear. Part I: The Michigan computer-graphic measuring system. J Prosthet Dent, 60:112-120, July 1988.
86. Howell, P.G.T. and Boyde, A.: Three-dimensional analysis of surfaces. In: *Analysis of organic and biological surfaces.* Echlin, P. ed. New York: John Wiley & Sons, 1984, pp 325-349
87. Abell, A.K.; Leinfelder, K.F.; Turner, D.T.: Accelerated microscopical evaluation of the clinical wear of composites. J Dent Res, 60:323, IADR abstr 52, 1981.

88. Abell, A.K.; Leinfelder, K.F.; Turner, D.T.: Microscopic observations of the wear of a tooth restorative composite in vivo. J Biomed Mate Res, 17:501-507, 1983.
89. Russ, J.C.; Hare, T.M.; Christensen, R.P. *et al*: SEM low magnification stereoscopic technique for mapping surface contours: application to measurement of volume differences in human teeth due to polishing. J Microsc, 144:329-338, December 1986.
90 Roberts, M.J. and Soderholm, K.J.M.: Comparison of three techniques for measuring wear of dental restorations. Acta Odontol Scand, 47:367-374, 1989.
91. Harrison, A.; Moores, G.E.; Glentworth, P.: Measurement of changes in surface profile due to wear using a ^{147}Pm β particle backscatter technique. I: Instrument development and application to controlled changes in surface profile. Wear, 93:37-52, 1984.
92. Glentworth, P.; Harrison, A.; Moores, G.E.: Measurement of changes in surface profile due to wear using a ^{147}Pm β particle backscatter technique. II: Application to the simulated wear of dental composite resin and amalgam restorations. Wear, 93:53-62, 1984.
93. DeLong, R.; Peterson, R.; Douglas, W.H.: A laser profiling system for measuring wear of dental materials. J Dent Res, 68:907, IADR abstr 328, 1989.
94. Willer, J. and Steinbichler, H.: Abdruckloses, optisches Verfahren zur Erfassung und Wiedergabe präpärierter Zahnformen. ZWR Dtsch Zahnärztebl, 97:240-242, March 1988.
95. Mjör, I.A.: A regulatory approach to the formulation of assessment criteria for posterior composite resins. Quint Int, 18:537-542, August 1987.
96. Ramfjord, S.P. and Ash, M.M.: *Occlusion*. 2nd ed. Philadelphia: W.B. Saunders, 1971.
97. Bloem, T.J.; McDowell, G.C.; Lang, B.R. *et al*: In vivo wear. Part II: Wear and abrasion of composite restorative materials. J Prosthet Dent, 60:242-249, August 1988.
98. Rekow, D.: Computer-aided design and manufacturing in dentistry: A review of the state of the art. J Prosthet Dent, 58:512-516, October 1987.
99. Rekow, E.D.; Erdman, A.G.; Speidel, T.M.: An update on the state-of-the-art of CAD/CAM in dental prosthodontics. In: Ninth Annual conference of the Engineering in Medicine and Biology Society: IEEE, 733-734, 1987.
100. Duret, F.; Blouin, J.L.; Duret, B.: CAD-CAM in dentistry. J Am Dent Assoc, 117:715-720, November 1988.
101. Mörmann, W.H.; Brandestini, M.; Lutz, F.: Das Cerec-System: Computergestützte Herstellung direkter Keramikinlays in einer Sitzung. Quintessenz, 38:1-14 report 6962, March 1987.
102. Mörmann, W.H.; Brandestini, M.; Lutz, F. *et al*: Chairside computer-aided direct ceramic inlays. Quint Int, 20:329-339, May 1989.
103. Young, J.M. and Altschuler, B.R.: Laser holography in dentistry. J Prosthet Dent, 38:216-225, August 1977.
104. Groves, D.; Lalor, M.J.; Cohen, N. *et al*: A holographic technique with computer aided analysis for the measurement of wear. J Phys E Sci Instrum, 13:741-746, July 1980.
105. Dirtoft, B.I.:Dental holography - earlier investigations and prospective possibilities. Adv Dent Res, 1:8-13, October 1987.
106. Williams, A.R.: Light sectioning as a three-dimensional measurement system in medicine. J Photogr Sci, 25:85-92, 1977.
107. Frobin, W. and Hierholzer, E.: Rasterstereography: A photogrammetric method for measurement of body surfaces. Photogram Eng Remote Sens, 47:1717-1724, December 1981.
108. Frobin, W. and Hierholzer, E.: Automatic measurement of body surfaces using rasterstereography. Part I: Image scan and control point measurement. Photogrammetric Eng Remote Sens, 49:377-384, March 1983.
109. Dunn, S.M.; Keizer, R.; Desjardins, P.J. *et al*: Accuracy of structured light system in measuring surface contours. J Dent Res, 68:236, IADR abstr 442, 1989.
110. van Rijn, L.J.; Boering, G.; ten Bosch, J.J.: Determining three-dimensional facial shape by means of laserscanning. J Dent Res, 65:799, IADR abstr 660, 1986.
111. Turner-Smith, A.R.: A television/computer three-dimensional surface shape measurement system. J Biomechanics, 21:515-529, 1988.
112. Tsutsumi, S.; Fukuda, S.; Tani, Y.: 3-D image measurements of teeth and alveolar ridge. J Dent Res, 68:924, IADR abstr 465, 1989.
113. Yu, Y.S.: Accuracy and dimensional stability of replica dies in relation to dental impression materials. Leuven, Belgium: Katholieke Universiteit, 1988. Thesis.

GROWTH DISTURBANCES AFTER MIDLINE FRACTURES IN CHILDHOOD

Twelve patients who had suffered midface fractures during their childhood were examined for skeletal deformities of the facial skull. The cephalometric data showed that neither the position nor the inclination of the maxilla were significantly different from normal anatomy. No correlation was found between the age, the severity of injury, surgical treatment, and resulting deformity.

Schliephake, H. *et al*: Wachstumsstörungen nach Frakturen des Mittelgesichtes im Kindesalter. Dtsch Zahnärztl Z, 45:819–822, Dezember 1990.

Twenty-four-month clinical trial of visible-light-activated cavity liner in young permanent teeth

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The clinical effectiveness of cavity liners/capping agents for treatment of carious primary and young permanent teeth has been well documented in many previous investigations.[1-7] Indirect pulp capping procedures have become more popular as evidence indicates a reduction of bacteria within the infected dentin.[8-10] Specific types of capping agents containing calcium hydroxide (Dycal and New Improved Dycal) have demonstrated the effectiveness of calcium hydroxide as an effective cavity liner/capping agent.[11,12]

This report is a summary of a two-year clinical trial of a visible light activated calcium hydroxide (VLC-Dycal), which is a calcium hydroxide-containing resin polymerized by a visible light, now marketed as Prisma VLC-Dycal (L.D. Caulk Company). VLC-Dycal is composed of calcium hydroxide, with a barium sulfate filler dispersed in a specially formulated urethane dimethacrylate resin. An *in vivo* study of small pulpal exposures in primate teeth and human primary teeth showed that VLC-Dycal was nontoxic and effectively assisted in reparative dentin formation.[13,14] The antimicrobial effect of VLC-Dycal was compared to self-curing products *in vitro* and was reported to be equally effective.[15]

The mechanism by which Ca $(OH)_2$ liners perform clinically is not clearly understood.[16] Pulp tissue is capable of forming a reparative dentin over pulp exposure.[17-20] Calcium ion released from the liners may or may not be incorporated in the matrix of the reparative dentin.[16,18,21]

The release of Ca^{++} ion was reported to be distinctly different among five commercial pulp capping agents.[22] An *in vitro* study reported that VLC-Dycal released Ca^{++} over a six-day period, but at a much lower rate (5 times less) than a self-curing liner (Life-Kerr).[23]

A six-month preliminary clinical evaluation of VLC-Dycal on young permanent teeth showed the material to be an effective cavity liner.[24] This study was begun at the University of Michigan, School of Dentistry in late August 1985. The objective of this study was to evaluate the clinical effectiveness of VLC-Dycal as a cavity liner in young permanent teeth for a period of twenty-four months.

METHODS AND MATERIALS

A population of 111 patients was selected for treatment from the Pediatric Dentistry Clinics of the University of Michigan Dental School and Mott Children's Health Center. One hundred fifty-two young permanent teeth were included in the study. Preoperative posterior bitewings or periapical radiographs were taken, and the

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Table 1 ☐ Clinical findings.

Criteria	Ratings
Percussion	No response
Cold	Slight
Hot	Moderate
Sweets	Severe
Mobility	
Criterion added at recall	
Fistula formation	Present/Absent

Table 2 ☐ Radiographic criteria (posterior bitewing and/or periapical).

Bone loss in bifurcation
Bone loss in another area
Periapical pathology
Reparative dentin
Recurrent caries
Evidence of resorption

Table 3 ☐ Indirect pulp capping (IPC).

Definition: All decay removed except over the pulp chamber
Baseline data recorded:

1) Cavity depth
   a) minimal thickness of remaining dentin
   b) questionable exposure
2) Decay left over pulp chamber
   a) 1mm. in diameter
   b) 2-4mm. in diameter
   c) greater than 5mm. in diameter
3) Texture of decay left
   a) firm
   b) leathery
   b) granular

Table 4 ☐ Direct pulp capping (DPC).

Definition: A pulp exposure occurred when all decay was removed.
Baseline data recorded:

1) Cavity depth (independent of exposure site):
   a) ideal depth-(normal remaining dentin)
   b) deeper than ideal-(some remaining dentin)
   c) very deep-(minimal remaining dentin)
2) Size of exposure:
   a) 0.1 to 0.5 mm.
   b) 0.6 to 1.5 mm.
   c) greater than 1.6 mm.
3) Cause of exposure:
   a) mechanical
   b) traumatic fracture
   c) removal of caries
4) Exposure site:
   a) vital (no bleeding)
   b) vital (mild to severe bleeding)
   c) serious fluid
5) Method to control bleeding
   a) cotton pellet
   b) cotton pellet with epinephrine

Table 5 ☐ Complete caries removal (CCR).

Definition: All decay removed without an exposure.
Baseline data recorded:

Cavity Depth (independent of exposure site):
   a) deeper than ideal (some remaining dentin)
   b) very deep (minimal remaining dentin)

Table 6 ☐ Recall evaluation criteria.

Restorations
Intact, functional
Fracture of amalgam isthmus
Crevice at margin
High spot on restoration
Fracture of tooth surface
Visible marginal staining
Restoration lost
Recurrent caries

operative procedures were performed by dental staff and students. The usual operative procedures taught in Pediatric Dentistry at the University of Michigan School of Dentistry were adhered to during treatment of the teeth used in this study. Three different methods of deep caries removal were tested:

☐ Indirect Pulp Cap (IPC), where minimal decay was left only over the pulpal area and if all caries was removed, a direct pulp exposure would likely have occurred.

☐ Direct Pulp Cap (DPC).

☐ Complete Caries Removal (CCR), without a pulp exposure.

All procedures were performed in the Pediatric Dental Clinics under supervision of a faculty or staff member. A small amount of VLC-Dycal was placed on a paper pad just before use. No mixing was necessary. A Caulk Dycal metal applicator was used to place the material in the proper area. The 1/2 round ball tip of the Dycal applicator was 0.5 mm in diameter and was used to determine the depth of the material applied. The visible light delivered by a "Prisma Lite," exposed the material for 20 sec up to a depth of 1 mm. If a second increment was used, another 20 sec of visible light was delivered. When indicated, a straight fissure carbide bur was used at conventional speed to smooth the floor and remove any excess along the walls of the preparation, especially the enamel. The preparation was rinsed, cleaned, and inspected before placement of a varnish, and/or base, if indicated, and then a final restoration.

The specific method used (i.e. IPC, DPC, and CCR) was evaluated and recorded using specific guidelines. Preoperative clinical and radiographic findings, type of isolation, thickness of the VLC-Dycal and the restorative materials used were also recorded at baseline (Tables 1-6).

A clinical evaluation was performed at three months on a random sample of twenty-five young permanent teeth to determine whether any adverse reactions occurred as a result of the use of this new material. The teeth in the study were evaluated at six-month intervals for twenty-four months. At the recall visit, a clinical examination was performed and appropriate radiographs for each patient were secured.

The six-month recall evaluations were made in three groups: 1, Clinical Criteria; 2, Radiographic Criteria; and 3, Restorative Criteria (Tables 1,2,6). If a restoration failed, the tooth was removed from the study; but the VLC-Dycal was not considered to be a failure.

RESULTS

At baseline, 152 permanent teeth were treated with the VLC-Dycal liner. Of the 152 permanent teeth, 24 were second permanent molars, 112 were first permanent molars, 2 were premolars, and 14 were incisors. One hundred twenty teeth or 79 percent were asymptomatic. Thirty-three teeth were slightly sensitive to cold, hot, sweets, or percussion or exhibited mobility. Of these thirty-three teeth, the major irritant was cold, in 73 percent (24/33); sweet in 64 percent (21/33); hot in 33 percent (11/33); and mobility was noted in 9 percent (3/33). The most frequent combination was cold-sweets, 36 percent (12/33); followed by cold-hot, 18 percent (6/33); and sweets alone with 12 percent (4/33). All teeth were radiographically within normal limits, except for three permanent teeth that exhibited possible periapical morbidity.

In this study, VLC-Dycal liner was used in forty-two cases of IPC, eighteen cases of DPC, and ninety-two cases of CCR. Rubber dam isolation was used 84 percent of the time. Applications of the VLC-Dycal liner were classified as follows: fifty-eight, thin; eighty-two, medium; and twelve as heavy.

The restorations used were 125 amalgams, sixteen resins and eleven stainless steel crowns. The types of restorations were fifty-six percent (85/152) Class I occlusal amalgams; 27 percent (41/152) Class II amalgams; 7 percent (11/152) stainless steel crowns; and the remaining 10 percent were Class II, IV, and V amalgam or resin restorations.

At twenty-four months, 36 percent (54/152) of the permanent teeth were still available for evaluation. Forty-seven of forty- nine teeth evaluated were asymptomatic after twenty-four months. The pulps of five permanent teeth degenerated over the twenty-four months thus necessitating root-canal therapy. Thus over the twenty-four months, fifty-four (49 + 5 devital) were evaluated and five failed, for a 91 percent (49/54) success rate, with the use of VLC-Dycal (Table 7).

Among the five teeth that failed, three were DPC and two IPC. Two teeth, one DPC and one IPC had questionable periapical morbidity from the baseline radiograph. From the initial baseline data, all failures of DPC had very deep cavity depths, from 0.6 mm to large pulp exposures (Table 4). From the initial baseline data, all failures of IPC had questionable exposures from the cavity depth, 2-4 mm in diameter to greater than 5 mm in diameter of decay left over the pulp chambers and a granular texture of decay left behind (Table 3). Only one tooth failed by three months; otherwise at least twelve months elapsed before failures were noted clinically. None of the CCR teeth failed.

Of the fifty-four teeth evaluated at twenty-four months, fourteen were symptomatic at baseline. After twenty-four months, ten had no symptoms, but four had become devital. One tooth (DPC) with no baseline symptoms became devital by twenty-four months.

Of the fifty-four teeth evaluated at twenty-four months, VLC-Dycal liner was applied to thirteen as IPC, ten as DPC and thirty-one had CCR. Rubber dam isolation was used on 87 percent of the teeth evaluated. The thickness of the liner applied to twenty-one teeth was thin, medium on thirty teeth, and heavy on three teeth. The restorations evaluated were forty-six amalgams, two resins, and six stainless steel crowns (Table 7).

Of the original 152 teeth, three were removed from the study, due to fracture of the amalgam/enamel interface in Class I restorations. The fractures were not directly a result of the VLC-Dycal application.

Various thicknesses of VLC-Dycal were placed in the 152 teeth and of the five that failed, four had a medium

Table 7 ☐ Twenty-four months after treatment.

	No. of teeth	No. Of failures	Success rate in %
Procedure performed	54	5	91
DPC	10	3	70
IPC	13	2	85
CCR	31	0	100
Type of restoration	54	5	
Stainless steel crown	6	1	83
Amalgam	46	2	96
Composite (DRC only)	2	2	0
Type of tooth	54	5	
Incisor (DPC only)	2	2	0
First permanent molar	43	3	93
Second permanent molar	9	0	100
Isolation	54	5	
Rubber Dam	47	5	87
Cotton Rolls	7	0	100
Thickness of VLC Dycal	54	5	
Thin	21	0	100
Medium	30	4	87
Heavy	3	1	67

Moisture must be controlled in use of VLC-Dycal.

thickness of VLC-Dycal applied, and one had a heavy layer used.

DISCUSSION

VLC-Dycal is an effective cavity liner for young permanent teeth in which all caries is removed. This material was also effective as a liner for indirect pulp capping where only two of thirteen IPC treated teeth failed. Failure occurred more frequently, when the VLC-Dycal was used as a direct pulp capping agent (Table 7). Sawusch, in 1982, reported that New Improved Dycal was an effective agent for indirect pulp capping. Direct pulp capping has always had a high failure rate regardless of the material used clinically, and the results of this study using VLC-Dycal were consistent with reported findings.[4,5,12,19] All five failures from DPC and IPC had the lowest recorded conditions from the initial baseline data (Tables 3 and 4).

After twenty-four months, forty-six patients with fifty-four young restored permanent teeth were available for follow-up analysis. All of the original 152 teeth were selected from patients of the two institutions where a recall system was difficult to maintain because of the changing populations.

VLC-Dycal was found to be an easy material to apply clinically, but moisture contamination must be properly controlled or the material will not adhere to the cavity walls. The material was removed easily with a low-speed bur in unwanted areas of the preparation. The material seems to have a good resistance to deformation, when the permanent restorative material is condensed against it. The compression strength of VLC-Dycal is about 14,000 PSI as compared to self-curing Dycal, which is 4,000 PSI*. In the study, the clinicians reported that VLC-Dycal had good handling characteristics, even though the curing time seemed long (20 sec).

VLC-Dycal has been evaluated histologically in primates and in humans with good results.[13,14] The material is capable of bacterial inhibition and also releases calcium ions, but at a lower rate than a self-curing liner (Life).[15,16] The amount of calcium ion needed for reparative dentin formation has not yet been determined.[16,18,21]

*Data from L.D. Caulk, form #554990 (R-1/87), Milford, Delaware.

SUMMARY

A clinical study of young permanent teeth for twenty-four months evaluated the use of a new product, VLC-Dycal, as a cavity liner. VLC-Dycal is a light-activated calcium hydroxide cavity liner. After twenty-four months, VLC-Dycal had a 91 percent success rate used as a liner with young permanent teeth. From the fifty-four teeth evaluated at twenty-four months, only five were failures.

Failure occurred more frequently with DPC. Of the five teeth that became devital over the twenty-four months, three were DPC. The success rate for DPC was 70 percent. IPC had a success rate of 85 percent. None of the CCR procedures failed in the study.

Because of the improved physical properties, VLC-Dycal was evaluated in a clinical trial for biological properties and proved to be a useful cavity liner for young permanent teeth.

REFERENCES

1. Seltzer, S. and Bender, I.: *The dental pulp: Biologic considerations in dental procedures.* Philadelphia: J.B. Lippincott Co., 1984, p 400.
2. Zerosi, C.: Critical appraisal of the literature on deep carious lesions. Int Dent J, 20:297-330, June 1970.
3. Seltzer, S.: Classification of pulpal pathosis. In: *The biology of the human dental pulp.* M. Siskin, Ed. St. Louis: C.V. Mosby Co., 1973, pp 331-349.
4. Damele, J.: Indirect pulp capping. (Abstr) J Dent Res, 40:756, July-August 1961.
5. DeMaggio, J.J. and Howes, R.R.: Evaluation of direct and indirect pulp capping. (Abstr) J Dent Res, 40:24, March 1962.
6. Aponte, A.J.; Hartsook, J.T.; and Crowley, M.: Indirect pulp capping success verified. J Dent Child, 33:164-166, May 1966.
7. King, J.B.; Crawford, J.J.; and Lindahl, R.I.: Indirect pulp capping: bacteriological study of deep caries in human teeth. Oral Surg, 20:663-667, November 1965.
8. Fairbourn, D.R.; Charbeneau, G.T.; and Loesche, W.J.: Effect of improved dycal and IRM on bacteria in deep carious lesions. JADA, 100:547-552, April 1980.

9. Knight, G.W. and Marchelya, L.S.: The effect of dycal on bacterial metabolism and viability in deep carious lesions. Master's thesis, Ann Arbor, University of Michigan, School of Dentistry 1981, p 69.
10. Leung, R.L.; Loesche, W.J.; and Charbeneau, G.T.: Effect of Dycal on bacteria in deep carious lesions. JADA, 100:193-197, February 1980.
11. Sawusch, R.H.: Dycal capping of exposed pulps in primary teeth. J Dent Child, 30:141-149, 3rd Quarter 1963.
12. Sawusch, R.H.: Direct and indirect pulp capping with two new products. JADA, 104:459-462, April 1982.
13. Pameijer, C.H. and Stanley, H.R.: Histological response to a visible light curing Ca-hydroxide composition in primates. (Abstr) J Dent Res, 64:222, March 1985.
14. Stanley, H.R. and Pameijer, C.H.: Pulp capping with a new visible light curing Ca-hydroxide composition (Prisma VLC Dycal) Operative Dent, 10:156-163, Winter 1985.
15. Lado, E.A. and Stanley, H.R.: An in vitro study of bacterial inhibition by VLC calcium hydroxide pulp cap compounds. Ped Dent, 9:292-294, December 1987.
16. Schroder, U.: Effects of calcium hydroxide-containing pulp- capping agents on pulp cell migration, proliferation, and differentiation. J Dent Res, 64:541-548, April 1985.
17. Cox, C.F.; Bergenholtz, G.; Fitzgerald, M. *et al*: Capping of the dental pulp mechanically exposed to the oral microflora — a 5-week observation of wound healing in the monkey. J Oral Path, 11:327-339, August 1982.
18. Holland, R.; Pinheirs, C.E.; Mellow, W. *et al*: Histochemical analysis of the dogs dental pulp after pulp capping with calcium, barium and strontium hydroxides. J Endod, 8:444-447, October 1982.
19. Negm, M.; Grant, A.; Comb, E. *et al*: Clinical and histological study of human pulpal response to new cements containing calcium-hydroxide. Oral Surg, 50:462-471, November 1980.
20. Pisanti, S. and Sciaky, I.: Origin of calcium in the repair wall after pulp exposure in the dog. J Dent Res, 43:641-644, September-October 1964.
21. Attalla, M.N. and Noujaim, A.A.: Role of calcium hydroxide in formation of reparative dentin. J Canad Dent Assoc, 35:267-269, May 1969.
22. Shubich, I.; Miklos, F.L.; Rapp, R. *et al*: Release of calcium ions from pulp-capping materials. J Endod, 4:242-244, August 1978.
23. Straffon, L.; Hotz, P.; and Kowalski, C.J.: In vitro calcium release from four calcium hydroxide liners. Schweiz Monatsschr Zahnmed, 98:1067-1071, October 1988.
24. Straffon, L. and Corpron, R.: Clinical evaluation of light activated liner and capping agent. (Abstr) J Dent Res, 65:175, March 1986.

BRUXISM

Bruxism is a condition which has been clinically recognized since the late nineteenth century. Many theories have been postulated as to its cause, but an overwhelming majority of authors in recent years have agreed that the two major components involved in the aetiology of bruxism are psychogenic and occlusal factors.

There is not complete agreement in the literature on the definition of bruxism. Differences, however, lie in the degree or extent of the bruxing activity rather than any basic concept. All agree that it involves grinding and clenching of the teeth, while neither masticating nor swallowing. Some define it as occurring only while the subject is sleeping; others include in their definition this phenomenon occurring during wakefulness as well.

The diagnosis and treatment of bruxism has come under intense investigation, particularly in the past decade. Diagnostic procedures have ranged from clinical and anamnestic examination to electromyography, and to date the techniques involving the examination of the patient appear to be the most successful and practical.

Occlusal rehabilitation, a more radical and, if the patient is dentate, an irreversible approach, has been reported. Less frequently muscle relaxation exercises and massage of the masseter muscles, drug therapy and biofeedback techniques and acupuncture have been used.

The aetiology and treatment of bruxism remain controversial, and as long as the aetiology is uncertain, then the many different treatment regimes will continue. However, the strongest evidence of recent years centers around occlusal and psychogenic factors, and it is in these two areas that further investigation is required.

Faulkner, Keith D.B.: Bruxism: A review of the literature. Part II.
Aust Dent J., 35:355-361, August 1990.

Occlusal disturbances resulting from neglected submerged primary molars

Yocheved Ben-Bassat
Ilana Brin
Anna B. Fuks

The presence of primary molars in infraclusion, frequently called submerged primary molars, is a relatively common finding in children. Its prevalence varies among the different populations, ranging from 1.3 percent to 38.5 percent.[1,2] Extraction has been the most widely recommended treatment, in order to prevent complications.[3] A more conservative approach was suggested, however, by Kurol and Koch, in 1985.[4] These authors demonstrated that the majority of these teeth exfoliate spontaneously after a delay of approximately six months, and concluded that the negative effect of submergence on occlusal development is usually temporary. Despite these effects, the authors named above emphasize the importance of continual supervision of the developing occlusion. Failure to observe the submerged teeth periodically may lead to serious complications, exemplified in the following patients.

CASE 1

A 5.5-year-old girl was referred to the Orthodontic Clinic for consultation. Clinical examination revealed that all the primary teeth were present and in functional occlusion, except for the maxillary right second primary molar, which could not be detected intraorally (Figure 1a). A panoramic radiograph, taken on that occasion, disclosed the presence of the "missing" primary molar and the bud of the second premolar in an extreme mesial malposition. On the whole, the eruption and developmental dental ages corresponded well to her chronological age, and the first permanent molars were close to eruption (Figure 1b).

Extraction of the submerged primary molar at this stage, would imply the construction of a distal shoe space maintainer, an often difficult procedure. In order to simplify and minimize the chances of complications, it was recommended to postpone treatment, and perform both the surgical and orthodontic interventions immediately following the eruption of the first permanent molar of the affected segment. These considerations were clearly explained to the parents, and the importance of a close follow-up was emphasized. Despite all the instructions and explanations, patient and parent compliance was not attained, and the girl returned to the clinic only two years later. At this stage, the first permanent molars were fully erupted. The right maxillary permanent molar showed a severe mesial inclination, closing most of the space for the second premolar, and complicating the access for surgical removal of the ankylosed primary molar (Figures 2a and 2b).

A removable plate with a finger spring was used in an attempt to regain space and facilitate the removal

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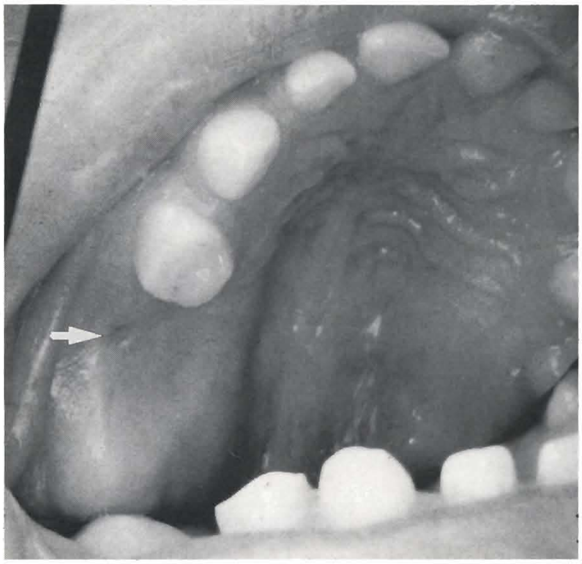


Figure 1a. Clinical photograph of the affected area when the patient was 5.5 years old. Note a pit in the mucosa (arrow) in the area corresponding to the second primary molar.

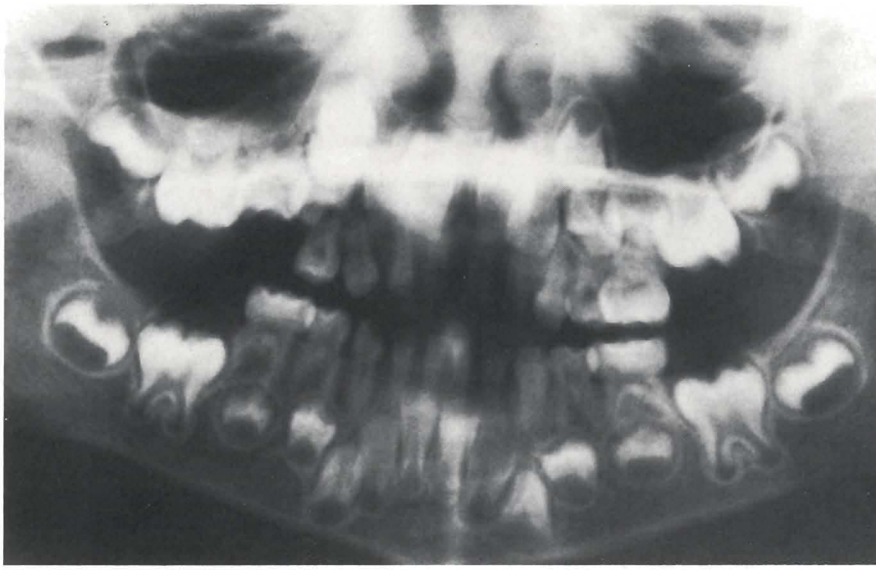


Figure 1b. Panoramic radiograph of the patient at the same age, disclosing the "clinically missing", severely submerged second primary molar. Notice the stacking of the buds of the premolars and the permanent canine.

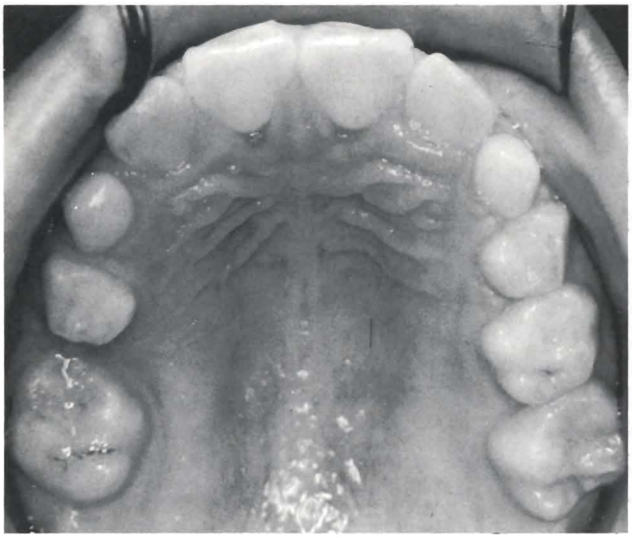


Figure 2a. Clinical photograph of the maxillary arch two years later. At this stage, the first permanent molars were fully erupted.

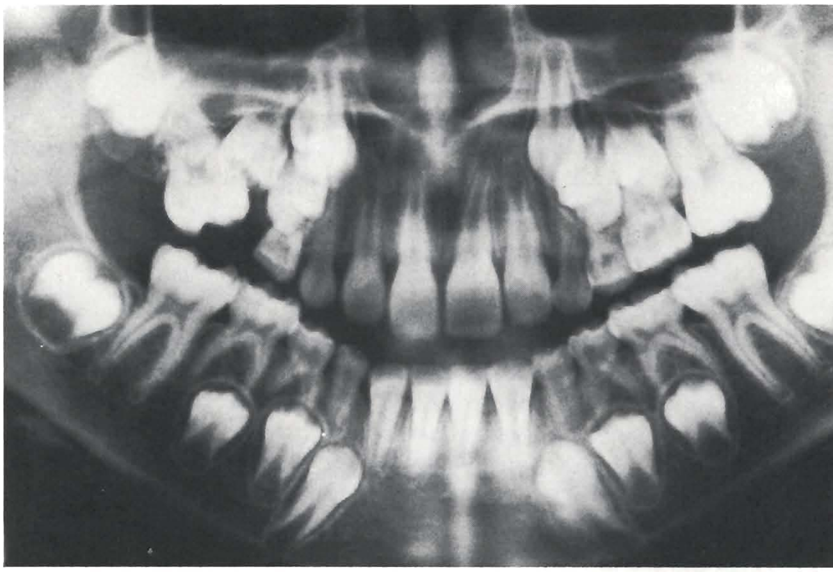


Figure 2b. Panoramic radiograph taken at the same time. The right maxillary permanent molar presents a severe mesial inclination, blocking the access for surgical removal of the ankylosed primary molar.

Figure 3. Close-up view of the affected area just before surgical exposure.

of the ankylosed tooth. Again patient compliance failed: the plate was lost and the girl returned to the clinic another two years later. The patient, nine years old now, was referred to the oral surgeon for the removal of the ankylosed primary molar. It was also decided to postpone orthodontic treatment, expecting better cooperation with the patient's maturity, and willingness to accept responsibility.

As expected from what could be seen in the radiograph (Figure 3), the surgeon was confronted, upon exposure, with two severe complications:

☐ The unerupted second premolar blocked the access to the submerged primary molar, and had to be extracted.

☐ The second primary molar was ankylosed to the floor of the maxillary sinus, which was penetrated upon removal of the tooth.

CASE 2

An 8.5-year-old girl presented at the Pediatric Dentistry Clinic with pain in her upper right buccal quadrant. Her medical history was noncontributory, except for the suspicion of factor XI deficiency, which was disclosed in her mother, following an episode of bleeding subsequent to a dental extraction.

The mother reported that the child was referred to an oral surgeon almost a year earlier, for treatment of submerging primary molars. She also presented a panoramic radiograph taken at that time, in which a severely submerged maxillary right second primary molar and a mesially inclined second premolar were disclosed. In addition, both mandibular first primary molars were in infraclusion, and the adjacent second primary molars were mesially inclined (Figure 4). In spite of these findings, the oral surgeon suggested waiting for normal exfoliation of the submerged teeth, considering treatment unnecessary. It should be stressed that no explanation was given to the parents on the importance of periodic follow-up.

At this stage, when the child presented to the clinic, the right maxillary second primary molar was completely submerged, with severe gingivitis in the buccal right quadrant. Swelling was detected in the right man-

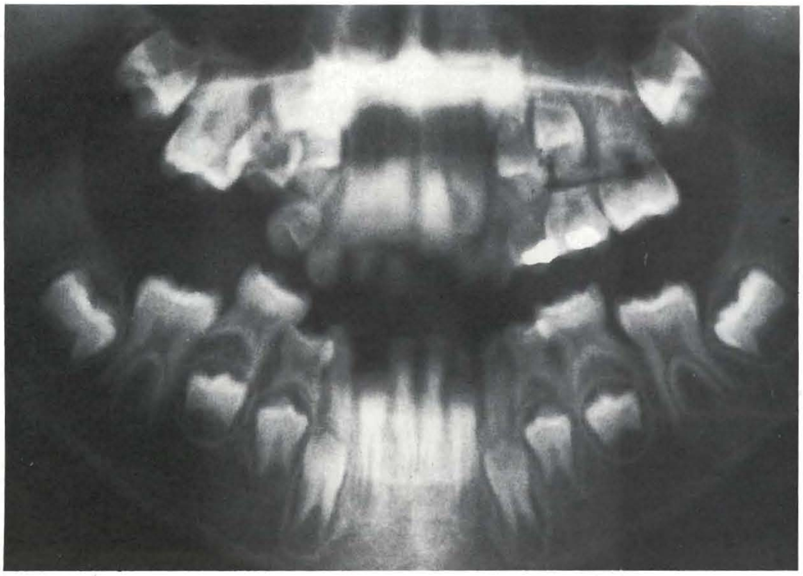


Figure 4. Panoramic radiograph of the patient described in case 2, at 7.5 years. One can observe the severely submerged maxillary right second primary molar, and a mesially inclined bud of the second premolar. Both mandibular first primary molars were in infraclusion, and the adjacent second primary molars were mesially inclined.

Submerged primary molars do not respond to orthodontic force.

dibular retromolar area, and the first permanent molar was unerupted (Figures 5a, 5b, 5c). The mandibular first primary molars were still in infraclusion, with the right side more accentuated than the left. Primary failure of eruption was suspected as a possible differential diagnosis.[5] A general approach to treatment included the following recommendations:

- ☐ Institute a strict oral hygiene regimen.
- ☐ Orthodontic intervention for regaining space in the maxillary right buccal quadrant.
- ☐ Surgical removal of the submerged maxillary primary molar and exposure of the mandibular first permanent molar.
- ☐ Periodical observation of the developing dentition, particularly of the infracluded mandibular first primary molars.
- ☐ Comprehensive orthodontic treatment at a later date.

DISCUSSION

A number of complications resulting from infraclusion of primary molars have been reported: tipping of the neighboring teeth, loss of space, and over-eruption of the antagonist. These were found, however, to have no long-term effect on occlusal development.[6] Conversely, Becker and Karnei-Reem reported a significant deviation of the dental interincisor midline toward the affected side, no loss of space, and infraclusion of the neighboring teeth. These findings may indicate a need for early intervention by extracting the submerged tooth. If this is not undertaken, periodical observation is mandatory. Failure of the oral surgeon to implement this, as described in case 2, caused a severe occlusal deterioration, further complicated by the unerupted first permanent molar.

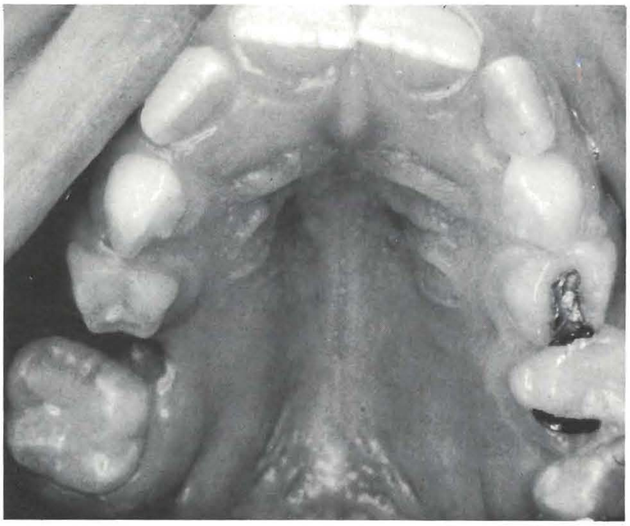
The coincidence of three unilaterally submerged primary molars and unerupted adjacent permanent molar, without any apparent reason for obstruction, could lead us to the differential diagnosis of failure of the primary tooth to erupt.[8]

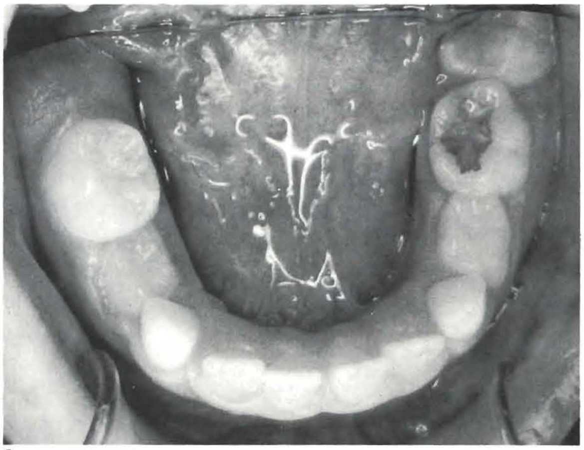
The patient described presents almost all the characteristics of this rare condition mentioned by Proffit and Vig, namely:

- ☐ Involvement of posterior teeth, including a first permanent molar.
- ☐ Enlarged follicle and crypt of the unerupted first permanent molar.
- ☐ Primary and permanent molars concomitantly affected.
- ☐ Condition affecting the teeth unilaterally.[8]

Confirmation of diagnosis could be attained upon surgical exposure of the unerupted permanent molar, since the teeth affected by this condition are not ankylosed, and can be moved within the crypt.

Distinguishing between lack of eruption due to some external interference and primary failure of eruption is important clinically, because the latter condition does not respond to the application of orthodontic force. Another important point is that cases of submersion of primary molars should always be discussed with the parents, and the possible complications clearly explained, if the condition is left unattended. Since it is difficult, if not impossible, to predict exactly the extent of parent and patient compliance, a rigid periodic recall schedule should follow the explanations given. When permanent molars are involved as well, a differential diagnosis of primary failure of eruption should be considered.


a.


b.


c.

Figures 5a, b, c. (clockwise, from top left): Clinical photographs of the same patient at the age 8.5 years. a. Maxillary occlusal view showing space closure. b. Mandibular occlusal view showing severe submergence of the first right primary molar, moderate submergence of its contralateral, and the lack of eruption of the first right permanent molar. c. Lateral view of the resulting malocclusion in the area.

REFERENCES

1. Via, W.F.: Submerged deciduous molars: familial tendencies. J Am Dent Assoc, 69:127-129, August 1964.
2. Steigman, S.; Koyoumdjisky-Kaye, E.; and Matrai, Y.: Submerged deciduous molars in the preschool children: an epidemiologic survey. J Dent Res, 52:322-326, March-April 1973.
3. Messer, L.B. and Cline, J.T.: Ankylosed primary molars: results and treatment recommendations from an eight-year longitudinal study. Pediatr Dent, 2:37-47, January 1980.
4. Kurol, J. and Koch, G.: The effect of extraction of infraoccluded primary molars. A longitudinal study. Am J Orthod, 87:46-55, January 1985.
5. Proffit, W.R. and Vig, K.W.L.: Primary failure of eruption: a possible cause of posterior open bite. Am J Orthod, 80:173-190, August 1981.
6. Kurol, J. and Thilander, B.: Infra-occlusion of primary molars and the effect on occlusal development. A longitudinal study. Eur J Orthod, 6:277-293, November 1984.
7. Karnei-Reem, R.: Infraocclusion and its effect on the dental arch. DMD Thesis, Hebrew University, Jerusalem, Israel, 1990.

Hereditary opalescent dentine: variation in expression

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The term *dentinogenesis imperfecta* was coined by Roberts and Schour when they described the brown opalescent teeth found in patients with osteogenesis imperfecta and noted the similarity to the opalescence described by Skillen and Finn as Hereditary Opalescent Dentine.[1-3] Unfortunately the term *dentinogenesis imperfecta* has been applied to the tooth defects found in *osteogenesis imperfecta* as well as to the isolated trait.

Although there are clinical, radiographic, and histological characteristics shared by the two dentine abnormalities, there is no genetic evidence to suggest that they involve mutations at the same locus. Family studies show conclusively that both conditions do not occur within the same kindred and are not variations, therefore, in gene expression.[4]

The isolated type of dentinogenesis imperfecta is an autosomal dominant disorder with almost 100 percent penetrance, in which dentine is selectively affected.[5,6] The frequency of inheritance is said to be 1:8000.[6] It is characterized clinically by opalescent or translucent teeth, which darken with age, and range in color from light brown through green brown to dark purple brown. Both dentitions are affected, the primary dentition being more affected than the permanent. The teeth have bulbous crowns with a cervical constriction and have short pointed roots, often with periapical areas present. The pulp chambers and canals become progressively obliterated after eruption and the enamel tends to chip away from the occlusal surfaces.[7]

In order to avoid confusion with the type of dentinogenesis imperfecta that occurs in association with osteogenesis imperfecta, the use of the term *hereditary opalescent dentine* should be restricted to the isolated trait.

The histological features are variously reported as normal to hypomatured enamel, smooth to accentuated amelodentinal junction, normal mantle dentine, and irregular dentine and dentinal tubules.[4,7]

For both the isolated trait and dentinogenesis imperfecta associated with osteogenesis imperfecta, the genetic abnormality appears to occur because of defective biosynthesis of Type I collagen.[8,9]

FAMILY CASE REPORT

Clinical proband characteristics

The proband, a Caucasian girl six years of age, was referred to the Pedodontics Department of the Dental School for assessment of discolored teeth. Clinical ex-

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Figure 1. Proband's dentition showing tooth discoloration.

amination showed that her teeth had a dark brown opalescence with some loss of occlusal enamel (Figures 1,2).

Radiographs demonstrated complete obliteration of the pulp chambers in all the primary teeth. Pulpal obliteration in the crowns of the lower lateral incisors had occurred before eruption. Crowns of the primary and permanent teeth were bulbous with marked cervical constrictions and the roots of the primary teeth, while of a reasonable length, were very narrow (Figure 3).

Histological sections obtained from an exfoliated primary upper incisor showed no abnormalities in the enamel structure. The mantle dentine appeared normal with well-organized dentinal tubules (Figure 4). Adjacent to the mantle dentine was a zone of poorly mineralized dentine in which tubule confluence was not evident (Figure 5). The remaining dentine was characterized by a dysplastic appearance with amor-

Figure 2. Evidence of wear of the proband's dentition.

phous areas and interglobular dentine (Figure 6). Although orientated mainly in the pulpal direction, the tubules were short and varied in width. These short,

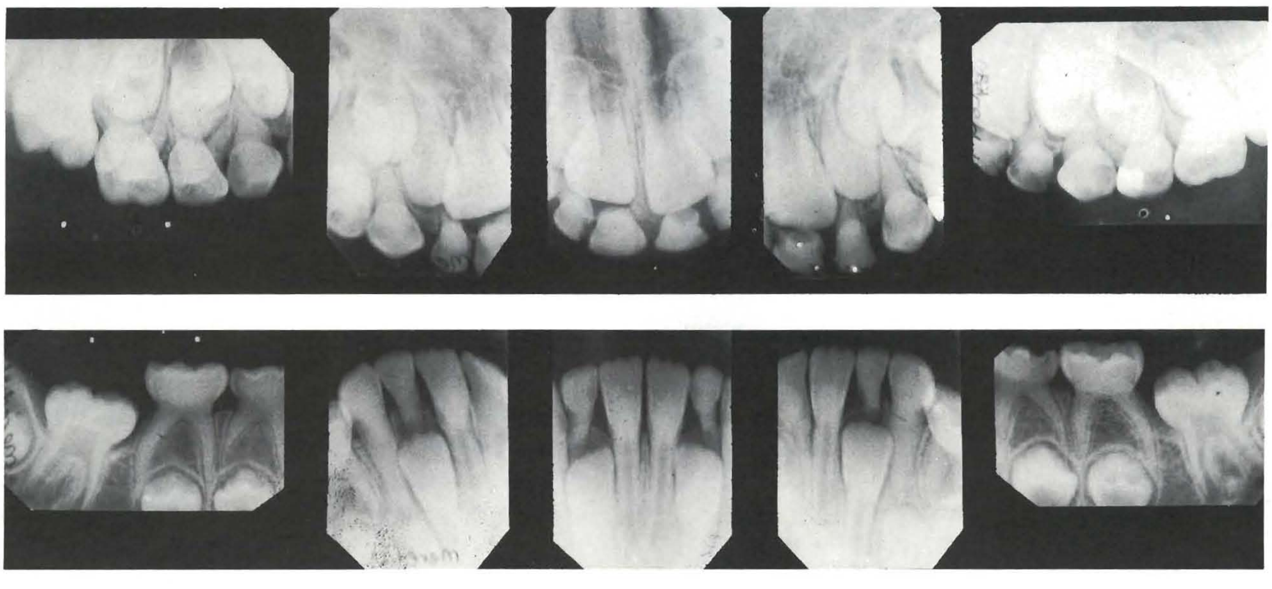

Figure 3. Radiographs of proband revealed pulpal obliteration of primary and developing permanent teeth.

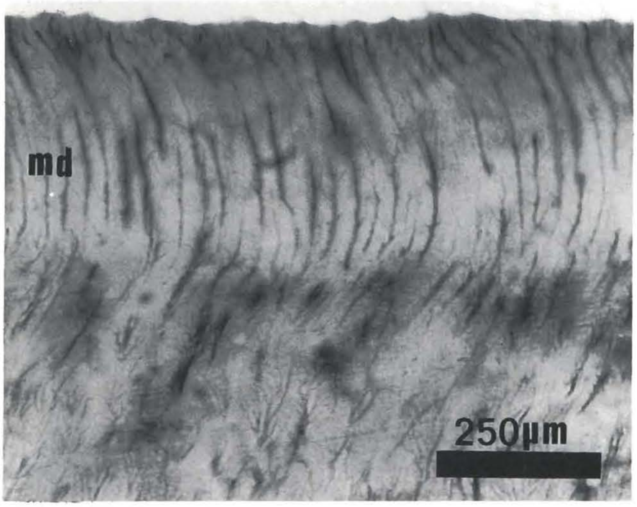

Figure 4. Cresyl-fast violet section. Below the mantle dentine (md) tubule confluence was lost and increased branching of dentinal tubules observed.

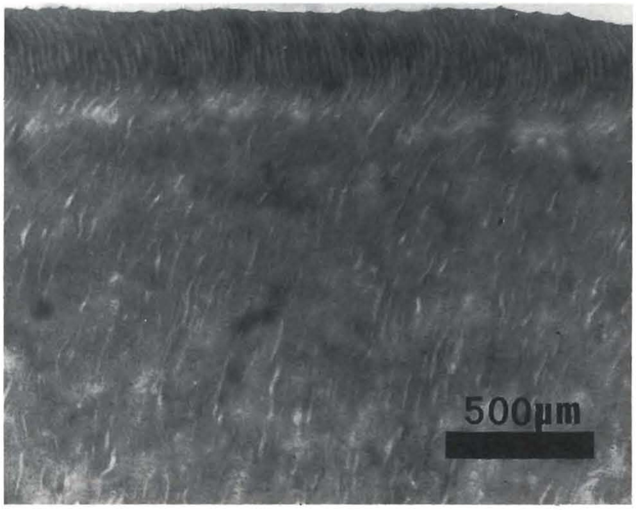

Figure 5. Hematoxylin and eosin section showing the zone of reduced mineralization below the mantle dentine.

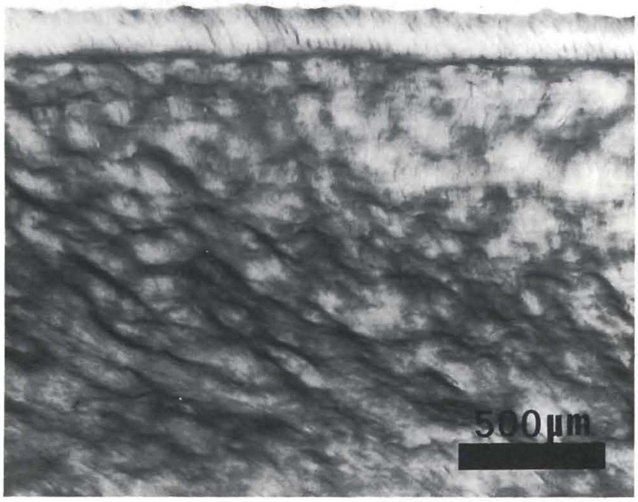

Figure 6. Cresyl-fast violet section showing the dysplastic appearance of the dentine.

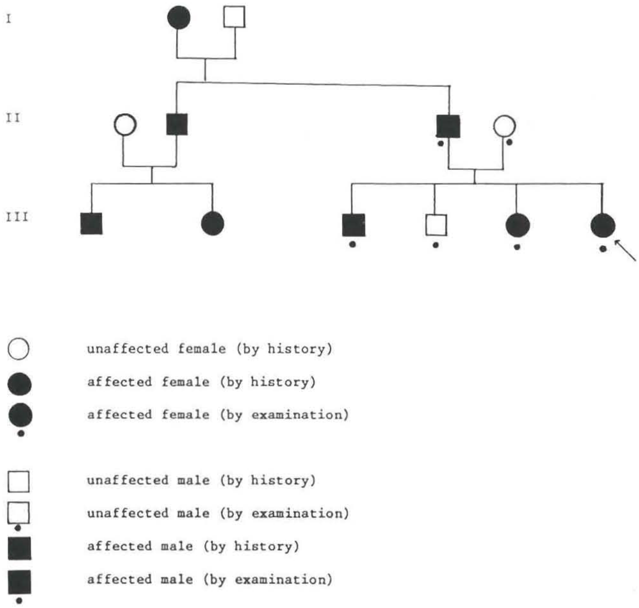

Figure 7. Family pedigree.

abnormally shaped tubules branched in a disorientated pattern (Figure 4). Scalloping of the dentinoenamel junction was observed on the labial surface, but appeared as a smooth junction on the lingual surface of the tooth.

Family pedigree

A family pedigree chart showing eight affected members spanning three generations is illustrated (Figure 7). Two siblings, a girl nine years of age and a boy thirteen years of age are also affected by dentine abnormalities. The remaining child, a boy of eleven years, was not affected (Figures 8-10).

Both dentitions of the nine-year-old girl showed a brown opalescence with, as yet, no marked loss of enamel, particularly for the permanent dentition (Figure 8). Radiographically, obliteration of the pulp chambers and progressive obliteration of the root canals were

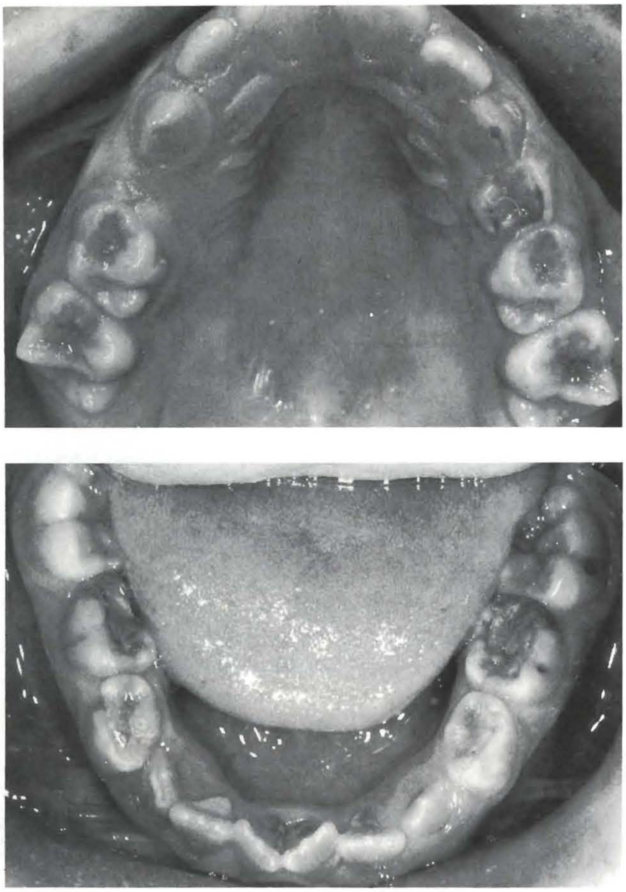

Figure 8. Dentition of the affected sister.

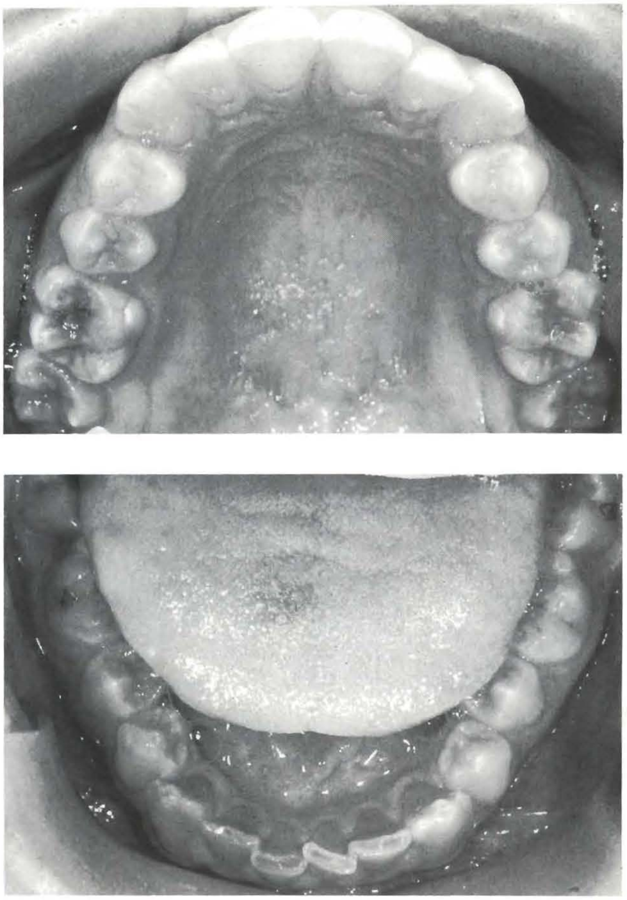

Figure 9. Dentition of the affected brother.

evident. Once again the roots were short and narrow without periapical radiolucencies (Figure 11). The six maxillary anterior teeth in the permanent dentition of the thirteen-year-old boy were only minimally affected (Figure 9). The radiographs showed the six upper anterior teeth were normal, except for areas of dystrophic calcification present in the pulp chambers of the maxillary incisors (Figure 12).

Figure 10. Dentition of the unaffected brother.

Figure 11. Radiographs of the affected sister show bulbous crowns and pulp obliteration.

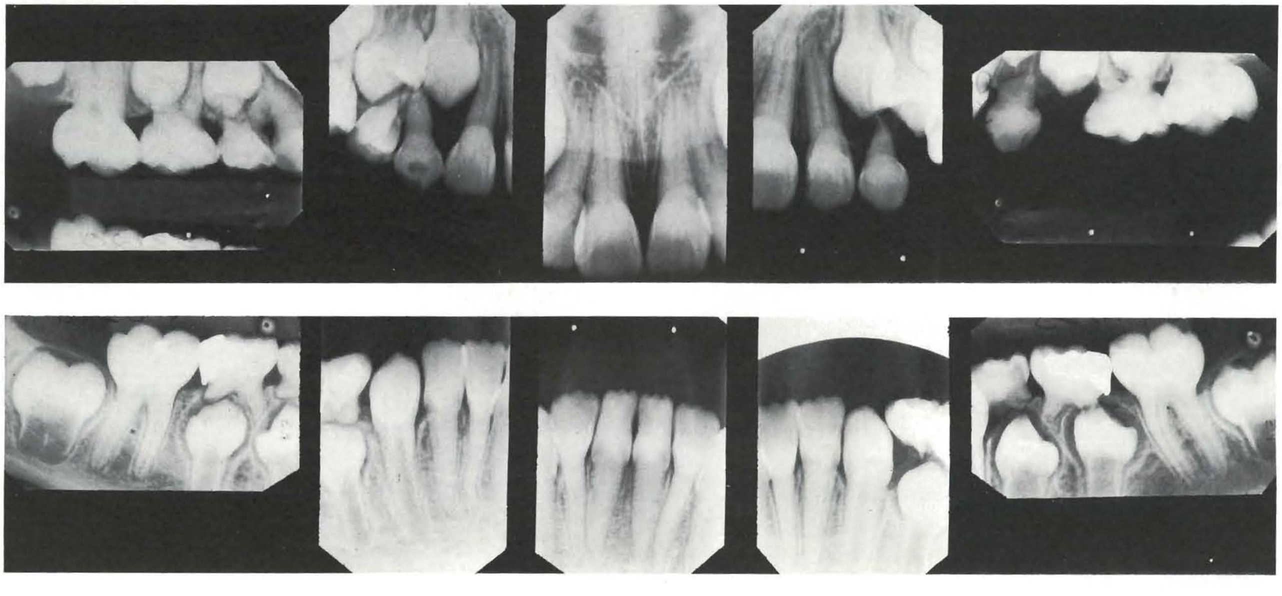

Figure 12. Radiographs of the affected brother show pulpal obliteration of most teeth with the upper anterior teeth least affected. The molar teeth are less bulbous than those of the affected girls.

Five-year follow-up

Five years after the initial examination, there was no evidence of occlusal wear or enamel fracture in the proband's dentition. The lower permanent incisors were the most discolored teeth and incisal wear was evident. The upper incisors were aesthetically pleasing and although calcifying, only slight opalescence was present (Figure 13). In time, progressive discoloration could prove to be unacceptable to the patient.

This patient will be continually monitored for changes in her dentition. During the mixed dentition stage, occlusal interference may result in a disturbance of the harmonious relationship between centric relation and centric occlusion, triggering tooth grinding in an attempt to eliminate any interferences. In this patient, the lack of posterior support due to wear of the primary teeth and subsequent eruption of the permanent incisors resulted in the exposure of the lower incisors to greater occlusal forces. There is no evidence, however, of enamel cleaving from the underlying dentine in the permanent dentition.

Should nocturnal bruxing cause incisal wear, short term therapy with a soft occlusal splint would reduce the loss of tooth structure. These splints allow for the continued eruption of the teeth. Once the permanent dentition has erupted and stabilized, occlusal equilibration will aid in the equal distribution of occlusal forces and minimize the risk of tooth fracture.

Dental examination of the affected siblings five years after the initial examination showed slight discoloration of the upper permanent teeth, no cleaving of enamel from the underlying dentine, minimal tooth wear and continuing obliteration of the pulp canals.

Figure 13. Proband's dentition at the five-year follow-up. The upper permanent incisors are aesthetically acceptable.

DISCUSSION

Hereditary opalescent dentine is said to follow a pattern of nonsex linked dominant inheritance. An interesting feature of this family, however, is that both girls are more severely affected than the boys. The apparent sexual dimorphism is difficult to explain, although one investigator reported a case of dentinogenesis imperfecta in a male child in which the four maxillary permanent incisors were normal.[10] In an attempt to explain this anomaly, it is suggested that as the maxillary incisors are the only teeth that develop in the median nasal process, this area may for some reason be exempt from the genetic abnormality of dentinogenesis imperfecta.[10] The affected male child in this family, however, has minimal involvement of the canines (which develop in the maxilla) as well as the other four maxillary incisor teeth. The calcified masses present in the maxillary

Early diagnosis
is essential.

incisors are reminiscent of the calcifications that can occur in dentine dysplasia.

Since the primary dentition is usually more severely affected than the permanent dentition, early diagnosis and treatment of patients suffering from hereditary opalescent dentine is essential. Fracture and loss of the protective enamel surface due to defects in the underlying dentine lead to rapid attrition of the crown height. This cleaving may not occur at the dentinoenamel junction whether or not it is scalloped, but rather within the dentine itself in the zone of reduced mineralization or in the remaining dystrophic dentine.

To minimize the risks of dental wear these patients should be monitored regularly by making models showing occlusal facets, crown height, and loss of tooth structure. Minor orthodontics and soft splints protect the dentition against wear and occlusal adjustments will provide for an even distribution of forces.

The hereditary opalescent dentine present in this family can be differentiated from dentinogenesis imperfecta associated with osteogenesis imperfecta by the lack of signs of a generalized disorder such as blue sclera, flaccid ligaments, and brittle bones. These children also do not suffer from dentine dysplasia, which is characterized by less marked color change in the teeth, very short or absent roots with many radiolucent areas and different histologic dentine changes.

The sexual dimorphism in the distribution of the condition in this family questions the accepted pattern of inheritance for hereditary opalescent dentine. Variation in the expression of the genetic coding is present within the family and within the individual dentitions. While the classic signs of hereditary opalescent dentine are present, unexplained variations were recorded, such as pulp stones, lack of discoloration of upper incisors and canines, minimal tooth wear, and females being more severely affected than males.

REFERENCES

1. Roberts, E. and Schour, I.: Hereditary opalescent dentine (dentinogenesis imperfecta). Am J Orthodont, Oral Surg, 25:267-276, March 1939.
2. Skillen, W.G.: Histologic and clinical study of hereditary opalescent dentin. J Am Dent Assoc, 24:1426-1433, September 1937.
3. Finn, S.B.: Hereditary opalescent dentine. An analysis of the literature on hereditary anomalies of tooth colour. J Am Dent Assoc & the Dental Cosmos, 25:1240-1249, August 1938.
4. Witkop, C.J. and Rao, S.: Birth defects, original article. Series Vol VII, 7:158, June 1971.
5. Bixler, D.: *Oral facial genetics* eds Stewart, R.E. and Prescott, G.H. St. Louis: The C.V. Mosby Co., 1976, Chapter 8, pp 230-236.
6. Witkop, C.J.: Hereditary defects of dentine. Dent Clin N Am, 19:25-45, January 1975.
7. Pindborg, J.J.: *Pathology of hard dental tissues*. Philadelphia: W.B. Saunders Co., 1970.
8. Gage, J.P.: PhD thesis. Studies on osteogenesis imperfecta dentine collagen, September 1986.
9. Takagi, Y.; Koshiba, H.; Kimura, O. *et al*: Dentinogenesis imperfecta: evidence of qualitative alteration in the organic dentine matrix. J Oral Path, 9:201-209, Second quarter 1980.
10. Pulver, F.: An atypical form of dentinogenesis imperfecta. J Dent Child, 29:123-135, Second Quarter 1962.

DIAGNOSIS OF APPROXIMAL CARIES LESIONS

From the results of this study, it was concluded that omission of radiographic examination will not result in a substantial loss of information in children less than twelve years old; but in children older than twelve years, it is advisable to include radiographic diagnosis for approximal surfaces.

de Vries, H.C.B. *et al*: Radiographic versus clinical diagnosis of approximal carious lesions.
Caries Res, 24:364–370, September-October 1990.

Postgraduate education

Do students in pediatric dentistry programs complete the course of training?

H. Barry Waldman, BA, DDS, MPH, PhD

The number of students withdrawing from the dental school in which they began their predoctoral dental program increased yearly between 1978 and 1985.* By 1985, almost four hundred first-year students (8.2 percent of the already decreasing dental school entering class size) withdrew from training (Table 1).

A slightly greater number of these first-year student withdrawals were for personal rather than academic reasons (52.8 percent vs 47.2 percent). Changing career objectives (the most frequent reason), transfers to other schools, and financial and/or family problems were some of the reported personal reasons for withdrawal.

Since the mid-1980s, the withdrawal rate of predoctoral students has continued to decrease, with personal reasons becoming the predominant explanation for withdrawal (an increase from 46.8 percent to 60.7 percent) (Table 2). It should be emphasized that the withdrawal rates decrease as students progress through their years of training in dental school (Table 3).

Although reviews by the American Dental Association's Council on Dental Education have provided annual reports on these many changes (particular extensive analysis of the reasons for withdrawals have been provided since 1986) little to no attention has been directed to withdrawal rates from postdoctoral advanced dental education programs. For example, were changes in the attrition rates in predoctoral programs in the 1980s mirrored by comparable developments in ad-

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Table 1 □ Dental school withdrawals/attrition, selected years 1979 to 1988.[1]

Year	1st year enrollment	Total 1st year withdrawals		Attrition		Repeaters		Transfers	
		No.	%	No.	%	No.	%	No.	%
1979	6,132	216	3.5%						
1981	5,855	290	4.9						
1983	5,274	357	6.8						
1985	4,843	399	8.2						
1986	4,554	316	6.9	226	4.9%	67	1.5%	23	0.5%
1987	4,370	289	6.6	212	4.9	66	1.5	11	0.3
1988	4,196	257	6.1	185	4.4	63	1.5	9	0.2

Table 2 □ Percent of freshman student withdrawals that were for personal reasons: 1984–1988.[1]

Year	Personal reasons
1984	46.8%
1985	52.8
1986	53.2
1987	53.3
1988	60.7

Table 3 □ Dental school withdrawals/attrition, by academic year: 1988.[1]

Academic year	Enrollment	Total withdrawals		Attrition		Repeaters		Transfers	
		No.	%	No.	%	No.	%	No.	%
I	4,196	257	6.1%	185	4.4%	63	1.5%	9	0.2%
II	4,127	136	3.3	84	2.0	37	0.9	15	0.4
III	4,169	57	1.4	33	0.8	16	0.4	8	0.2
IV	4,583	24	0.5	12	0.3	12	0.3	0	—

Table 4 □ Number of advanced dental education students and percent of students who completed the course of study by program: 1977.[2]

	Calendar year 1977								
	Dental school			Nondental school			Totals		
Program	Enter	Graduate	Percent complete	Enter	Graduate	Percent complete	Enter	Graduate	Percent complete
Dent. Pub. Health	4	2	50.0%	31	17	54.8	35	19	54.2%
Endodontics	114	112	98.2	20	32	*	134	144	*
Oral Path.	15	13	86.7	7	8	*	22	21	95.5
Oral & Max. Surgery	103	96	93.2	128	121	94.5	231	217	93.9
Orthodontics	280	261	93.2	24	26	*	304	287	94.9
Pediatric Dentistry	**124**	**129**	*	**52**	**40**	**76.9**	**176**	**169**	**96.0**
Periodontics	159	179	*	19	27	*	178	206	*
Prosthetics	110	103	93.6	42	58	*	152	161	*
Totals	909	895	98.5	323	329	*	1,232	1,224	99.4

* Greater than 100 percent. Not all students completed the course of studies in the usual period of time. Percentages greater than one hundred include some of these students.

vanced training programs? Are there differences in attrition rates in the various fields of training? Have the changing perceptions of the potential for pediatric dental practices been reflected in the completion rates in the training programs? The following presentation will review the limited material that is available on the attrition of students in advanced education programs in an effort to answer some of these questions and stimulate further reports on developments in advanced dental education programs. The review will include only those programs in the eight recognized specialty areas.

PROCEDURES

The percent of students completing particular programs were developed by comparing the data included by the American Dental Association in its publication "Annual Report on Advanced Dental Education" for the 1970s and 1980s to determine the number of graduates and the number of students in the respective entering classes. Note: varying lengths of the course of

*Unless otherwise indicated in this presentation, a specified year will indicate the start of an academic year: e.g. 1978 and 1985 represent, respectively, the 1978-79 and 1985-86 academic years.

studies exist for some programs (e.g. a minimum of two, three and four years of study, respectively, are required for pediatric dentistry, oral pathology, and oral and maxillofacial surgery programs. In addition, there have been changes in the titles of some courses. For purposes of this review, only "prosthetic-combined" programs were included in the prosthetic category).

Advanced training programs in general

Far more students are enrolled in specialty dental school training programs than in nondental school arrangements; except for those enrolled in surgical training programs, and in some years, dental public health programs.

In calendar years (CYs) 1977, 1984 and 1989, the overall completion rate was almost one hundred percent, except for a) nondental school based programs in CY 1984, and b) dental school based programs in CY 1989. There were differences between the completion rates, however, for the various specialty programs.

☐ Completion rates for students enrolled in dental public health programs consistently have been markedly lower (with rates as low as 20, 43, and 50 percent) than for students enrolled in other specialty training programs.

☐ Completion rates for students enrolled in oral pathology programs based in dental schools consistently have been below 90 percent.

☐ Completion rates for students who graduated from the other training programs in CYs 1977 and 1984 were in excess of 90 percent.

☐ Completion rates for students who graduated in CY 1989 from several dental school based programs decreased to 90 percent or less (Tables 4-6).

There exists a paucity of information, which should be corrected.

Pediatric dentistry programs

In the early 1980s, Meskin *et al* outlined a bleak future for pediatric dental practice, including:

☐ Pediatric dentistry appeared to be moving toward an excess supply.

☐ Waiting periods for patient appointments were exceedingly short.

☐ There were signs of practitioner dissatisfaction associated with unrealized income expectations.[3,4]

Notes: There has been a general decrease in the number of senior predoctoral dental students expressing an interest in a pediatric dentistry course of training.[5] Since 1975, the ADA annual reports on advanced education

Table 5 ☐ Number of advanced dental education students and percent of students who completed the course of study by program: 1984.[2]

	Calendar year 1984								
	Dental school			Nondental school			Totals		
Program	Enter	Graduate	Percent complete	Enter	Graduate	Percent complete	Enter	Graduate	Percent complete
Dent. Pub. Health	16	7	43.8%	18	9	50.0%	34	16	47.1%
Endodontics	102	106	*	21	21	100.0	123	127	*
Oral Path.	19	17	89.4	3	3	100.0	22	20	90.9
Oral & Max. Surgery	96	89	92.7	110	111	*	206	200	97.0
Orthodontics	262	269	*	22	20	90.9	284	289	*
Pediatric Dentistry	**119**	**119**	**100.0**	**39**	**38**	**97.4**	**158**	**157**	**99.4**
Periodontics	155	162	*	19	20	*	174	182	*
Prosthetics	44	87	*	26	30	*	70	117	*
Totals	813	856	*	258	242	93.8	1,071	1,108	*

* Greater than 100 percent.

Table 6 ☐ Number of advanced dental education students and percent of students who completed the course of study by program: 1989.[2]

Program	Dental school Enter	Dental school Graduate	Dental school Percent complete	Nondental school Enter	Nondental school Graduate	Nondental school Percent complete	Totals Enter	Totals Graduate	Totals Percent complete
Dent. Pub. Health	15	3	20.0%	10	8	80.0%	25	11	44.0%
Endodontics	114	103	90.4	16	16	100.0	130	119	91.5
Oral Path.	7	6	85.7	4	3	75.0	11	9	81.8
Oral & Max. Surgery	95	82	86.3	116	114	98.2	211	196	92.9
Orthodontics	265	267	*	37	36	97.3	302	303	*
Pediatric Dentistry	**130**	**113**	**86.9**	**35**	**34**	**97.1**	**165**	**147**	**89.1**
Periodontics	173	150	86.7	22	24	*	196	174	89.2
Prosthetics	118	122	*	36	39	*	154	161	*
Totals	917	846	92.5	276	274	99.3	1,193	1,120	93.9

Calendar year 1989

* Greater than 100 percent.

Table 7 ☐ Number of pediatric dental students and percent that completed the course of study: 1977, 1984, 1989.[2]

Year graduated	Dental school Enter	Dental school Graduate	Dental school Percent complete	Nondental school Enter	Nondental school Graduate	Nondental school Percent complete	Totals Enter	Totals Graduate	Totals Percent complete
1977	124	129	*	52	40	76.9	176	169	96.0
1984	119	119	100.0	39	38	97.4	158	157	99.4
1989	130	113	86.9	35	34	97.1	165	147	89.1

* Greater than 100 percent.

no longer provide information on first year enrollment as a percentage of first year program capacity.

Despite the ominous forecasts, the percent of students who completed their pediatric training increased (between CYs 1977 and 1984) to almost a hundred percent in both dental school and nondental school programs. During this period there was a decrease in both the number of entering students and graduates (Table 7).

By the second half of the 1980s, the prospects for pediatric dental practice had increased appreciably.[5] The entering number of students in pediatric dentistry programs increased slightly (but not to the level of the mid-1970s). While virtually all students enrolled in the nondental school based programs completed their courses of study, there was a decrease to 86.9 percent in the number of students enrolled in dental school programs who finished their courses of study (Table 7).

We just do not know

We just do not know very much about the reasons why advanced dental education students do not complete their courses of study. No doubt, the differences between predoctoral and postdoctoral attrition rates are related to the varying stages of career commitment. But little information is available to permit an exploration of the reasons why.

- ☐ Attrition rates in pediatric dentistry programs decreased when there are questions about the future of the specialty.
- ☐ Why these same attrition rates increased when the future of the specialty appears much brighter.

Could it be that there is an information lag and students are unaware of the actual developments in a particular period?

The difficulty is that there is a paucity of information about the students in advanced dental education programs. The ADA reports on predoctoral programs provide extensive information on attrition rates by gender, minority and ethnic status, and assorted personal and academic reasons. Rates of attrition for advanced training programs and the reasons for failure to complete the course training, essentially are not addressed in ADA reports.

Do students in pediatric dentistry programs complete the course of training? Well, some do not; the rate of attrition may be increasing (at least in dental school based programs); and we just do not know why. It would seem appropriate for the reports on advanced dental education by the ADA, (or even reviews by the particular specialty groups), to address the issues of attrition rates in advanced training programs, in the hope that the process of attrition would be understood better and to ensure the completed education of those for whom extensive efforts and finances have been provided.

REFERENCES

1. Council on Dental Education. Dental School Attrition. Supplement 4 to the 1989/1990 Annual Report on Dental Education. Chicago: American Dental Association.
2. Council on Dental Education. 1974/1975 through 1989/1990 Annual Report on Advanced Dental Education. Chicago: American Dental Association.
3. Meskin, L. *et al*: Entering the '80s: pediatric practice characteristics and practitioner satisfaction. Pediatric Dent, 3:241-245, September 1981.
4. Meskin, L. *et al*: Too many pedodontists? If so what then? Pediatric Dent, 4:119-123, June 1982.
5. Waldman, H.B.: 1980-1990: what a difference ten years have made in the future of pediatric dental practice. J Dent Child, 56:458-462, November-December 1989.

Demography

There really are children in poor health

H. Barry Waldman, BA, DDS, MPH, PhD

We tend to place people generally in stereotyped categories, often based upon precedents, experiences, biases or general expectations (e.g., all women in a dental office are dental hygienists or assistants and all males are the dentists). While we are aware that changes are occurring, it is difficult to alter long held perceptions and biases. In many instances this tendency to place individuals or various demographic groups into convenient categories often is reinforced by media portrayals (e.g., the somewhat confused but kindly grandparent in most television situation comedies).

Similarly, the stereotyped image of the levels of health in our communities has been presented so uniformly we (i.e., the general public) expect that children are in good health while older people are in failing health. For example, when was the last time you saw a handicapped child in a television program — except for a news spot or in some fundraiser? Young children are always those precocious wisecracking imps, — guaranteed to enliven any given situation comedy. Children in wheelchairs or with any visible maladies (except for a short-lived, benign item or two that keeps them out of school so that they can make it to the crucial ballgame) are "just too depressing" for the general audience and the show's rating.

But as we all know, there really are children in poor health in our communities. By continuing to shield the general public from the extent of these realities we

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Table 1 ☐ Number and percent of individuals less than twenty years of age whose health was considered as being fair or poor: 1987.[1]

Age	Number (in thousands)		Percent of all children	
	Fair	Poor	Fair	Poor
< 5 yrs.	399.9	72.7	2.2%	0.4%
5–9 yrs.	387.7	52.9	2.2	0.3
10–14 yrs.	279.7	49.4	1.7	0.3
15–19 yrs.	489.8	72.6	2.7	0.4
Total	1,557.1	247.6		

Table 2 ☐ Number and percent of children less than eighteen years of age whose health was considered as being fair and poor by family income: 1987.[1]

Family income	Number (in thousands)	Percent of all children
< $5,000	195.3	5.9%
$5,000–$9,999	276.0	5.3
$10,000–$19,999	420.5	3.6
$20,000–$34,999	276.8	1.6
$35,000–$49,999	126.9	1.2
$50,000 +	81.2	1.0

tend to foster the singular image that all is well and that efforts should be directed to provide care for other needy segments of our communities. Information is available from the recently published National Health Interview Survey (NHIS) on personal self health assessment by the general public, which provides a more realistic picture (based upon the perceptions of parents and guardians) of the general standards of health amongst our nation's children.[1] If we are to provide improved health services for these children, we must somehow extend the traditional, Norman Rockwell-image of our children to include the realities of life in the 1990s.

SOURCE OF INFORMATION

The information from the National Health Interview Survey is based on data collected by household interview in a continuing nationwide survey. Each week a probability sample of the civilian noninstitutionalized population is interviewed by personnel of the Bureau of Census. Responses for children and youths always are sought from adult family members. The 1987 NHIS sample was composed of 47,240 households containing 122,859 persons. The total noninterview rate was 4.7 percent.

Notes: 1. Because the questions refer to a person's health and not to the possible effects of any impairments, it is possible for severely impaired children to be classified as though their health were "excellent" and for children with no impairments to be classified as in "poor" health.

2. An earlier NHIS report on self assessment for 1978 was done. Because of changes in the general questionnaire format in the 1987 study, however, the current survey produces a lower estimate of the percent of persons assessed in the "fair" and "poor" health categories. Even though the levels of the estimates change because of the format, however, the pattern of the relationships between subgroups of the population (e.g. race, ethnicity, income, place of residence, etc.) as defined by health status categories is, in general, the same for both periods.[1,2]

CHILDREN IN GENERAL

In 1987, 1.8 million children were reported to be in fair or poor health.* Whereas in the general population, proportionately more females than males were reported to be in fair or poor health, for children under ten years of age, a higher percent of males than of females were reported to be in fair or poor health (Table 1).

VARIOUS DEMOGRAPHIC CHARACTERISTICS

Children in fair and poor health are not distributed uniformly throughout the population. Particular population groups of children have reported rates of fair and poor health that are four, five and as much as six times the rates of other groups.

By family income

There is an inverse relationship between family income and the percent of children with reported fair and poor health. Almost 6 percent of children in families with incomes below $5,000 compared to one percent of children in families with incomes of more than $50,000, were reported to be in fair or poor health (Table 2).

By race and ethnicity

Minority group children, particularly those in lower income families, have greater incidence of reported fair

Family income and child health are closely related.

*Respondents were asked to classify the health of family members into five categories, "excellent", "very good", "good", "fair" and "poor".

Table 3 ☐ Percent of children less than eighteen years of age whose health was considered as being fair and poor by race, ethnic origin, and family income: 1987.[1]

Race and ethnicity	Percent of all children	Family income < $20,000	Family income $20,000 +
Hispanic	4.2%	6.2%	2.0%
Puerto Rican	5.3	7.8	0.9*
Cuban	2.0*	3.6*	2.2*
Mexican	3.5	5.3	1.7*
Other	5.5	8.0	3.2*
White			
Hispanic	4.1		
Non Hispanic	1.8		
Black			
Hispanic	5.8*		
Non Hispanic	4.3		

*More than 30 percent relative standard error in the numerator of the percent.

Table 4 ☐ Percent of children less than eighteen years of age whose health was considered as being fair and poor by size of family, race and family income: 1987.[1]

Number in family	White	Black	Total	Family income < $20,000	Family income $20,000 +
2	3.6%	4.2%*	3.8%	4.7%	1.1%*
3	2.0	4.0	2.3	3.8	1.3
4	2.0	4.4	2.3	4.5	1.4
5 +	2.2	4.4	2.7	4.7	1.3

*More than 30 percent relative standard error in the numerator of the percent.

Table 5 ☐ Percent of children less than eighteen years of age whose health was considered as being fair and poor by geographic region and race: 1987.[1]

Region	White	Black	Total
Northeast	2.0%	3.0%	2.2%
Midwest	2.0	5.4	2.4
South	2.5	4.6	3.0
West	2.0	2.7*	2.1

*More than 30 percent relative standard error in the numerator of the percent.

Table 6 ☐ Percent of children less than eighteen years of age whose health was considered as being fair and poor by place residence and race: 1987.[1]

Place of residence	White	Black	Total
In MSA*	2.0	4.4	2.5
Central	2.8	4.3	3.3
Non-central	1.7	4.4	1.9
Not in MSA	2.4	4.1	2.5
Non-farm	2.4	4.1	2.5
Farm	2.4**	4.3**	2.4**

*Metropolitan Statistical Area
**More than 30 percent relative standard error in the numerator of the percent.

and poor health, than their nonminority counterparts (Table 3).

By family size

Children with no siblings in single parent families have a higher reported rate of fair and poor health than children in two parent families and families with greater numbers of children (Table 4).

Note: there have been dramatic increases in the number of single parent families. The number of single parent families more than doubled from 3.8 million in 1970 to 8.5 million in 1988 (from 12.5 percent to 24.8 percent of all families).[3]

By region

Overall, the percent of children with reported fair and poor health is higher in the Southern region than in other regions of the country. Among black children, the Midwestern region had the highest percent of children with reported fair and poor levels of health (Table 5).

By residence area

There were minimal differences in the rate of fair and poor health between white children living in the various residential areas, except for a lower rate for those children living in the noncentral areas of metropolitan areas. Similarly, there were virtually no differences in the rates for black children living in the various residential areas, except that the rates for black children living in all areas were almost double the rates for their white counterparts (Table 6).

SO WHAT DOES ALL THIS MEAN?

Increasingly the public's attention has been drawn to the horrors of child abuse, the consequences of substance-abuse by pregnant women on the health of new born infants, AIDS-infected children, and a variety of other particular conditions.[4] But limited attention has been directed to the totality of the less than satisfactory health status of the children in our communities.

The statements by parents and guardians can provide the necessary general information, but only if it is used to reach the general community, planners and legislative leaders. The enormity of the problem of improving the health status of our children takes on a particular urgency only when it is perceived in its true cumulative proportions. Fragmented presentations tend to diminish the critical nature of the problem.

But for many of the poor and minorities (and many of the not so poor and nonminorities), the health status of their children is a critical problem. Should we not use every means at our disposal to make the case that health services are needed for these children?

REFERENCES

1. U.S. Department of Health and Human Behavior, National Center for Health Statistics. Americans Assess Their Health: United States, 1978; 1987. Vital and Health Statistics. Data from the National Health Interview Survey, Series 10: No. 142; 174. DHHS Pub. No. (PHS) 83-1570; (PHS) 90-1502. Washington, D.C.: Government Printing Office, 1983; 1990.
2. U.S. Department of Health and Human Behavior, National Center for Health Statistics. Health, United States: 1981. DHHS Pub. No. (PHS) 82-1232. Washington, D.C.: Government Printing Office, 1981.
3. A Report together with Additional Views of the Select Committee on Children, Youth, and Families. U.S. House of Representatives. 101st Congress, first session. Washington, D.C.: Government Printing Office, 1989.
4. Fact Sheet: Women, addiction, and perinatal substance abuse. Select Committee on Children, Youth and Families. U.S. House of Representatives. April 19, 1990.

Acquired condylar hypoplasia: report of case

Case reports

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Degenerative arthritis of the temporomandibular joint (TMJ) was originally thought to be an adult condition. By the mid-nineteen-seventies, however, at least two reports stated that a significant number of patients were being seen by the age of twenty. Boering, in a study of 400 TMJ patients, found that 26 percent of these patients were age twenty or younger, and the first symptoms in 34 percent of the total number of patients seen occurred at an age under twenty.[1,2] These figures indicate that a significant number of TMJ patients experience their first symptoms during their childhood years.

It is well documented that the TMJ is subject to a variety of disturbances, which may include developmental anomalies, trauma, neoplastic diseases, and arthritides.[3] When these disturbances occur before the age of twenty, asymmetries of the mandible may develop because of involvement of the growth site located in the condyle. These asymmetries are important, because alteration in function on one side may simultaneously affect the function on the other side and lead

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to occlusal changes such as ipsilateral or bilateral posterior crossbite.[4]

Currently, there are three accepted types of developmental disturbances of the mandible, which are usually unilateral: condylar aplasia, condylar hyperplasia, and condylar hypoplasia.[3]

Condylar aplasia is total failure of the mandibular condyle to develop. When this occurs unilaterally, patients often present with a severe facial deformity. Characteristically the mandible will deviate dramatically to the affected side and exhibit a severe retrognathic malocclusion.[4]

Unilateral condylar hyperplasia is characterized by an enlargement of the condyle or elongation of the neck of the condylar process. There is no antegonial notching on the affected side and the lower border of the mandible may actually appear bowed. This lower border becomes rounded as the neck of the condylar process elongates causing mandibular displacement away from the maxilla. There is also a tendency for the teeth to erupt in an attempt to maintain occlusion, causing an increase in the height of the alveolar process.[4] A slowly progressive elongation of the face usually occurs with deviation of the chin to the unaffected side.[3] On the unaffected side, there is a normal size body and ramus. Patients will have an Angle Class I or an Angle Class III type occlusion.[4]

Condylar hypoplasia can be congenital or acquired. Congenital hypoplasia is of idiopathic origin and is present either at birth or begins very early in life. Acquired hypoplasia is due to any agent that interferes with normal development of the condyle. Examples of acquired hypoplasia can be: traumatic forceps delivery at birth; sudden external impact trauma during early life; overexposure to radiation treatment for skin lesions such as hemangiomas or birthmarks that lie over the TMJ; spreading infections; local inflammation in rheumatoid arthritis; or a circulatory disorder in the proximity of the TMJ.[3] Patients with unilateral condylar hypoplasia usually exhibit mandibular deformity. These deformities may include a short, wide ramus, shortening of the body of the mandible, antegonial notching, and fullness of the face on the affected side. On the unaffected side there will be a relative elongation of the mandibular body and flatness of the face. Generally, a Class II malocclusion is present due to the overall mandibular underdevelopment.[4]

Boering in 1966 concluded that another developmental disturbance of the mandible exists, which is a juvenile form of temporomandibular arthrosis.[1] Boering's term, *arthrosis deformans juvenilis*, is synonymous with the term juvenile degenerative arthritis. Boering defined juvenile degenerative arthritis as a degenerative process of the temporomandibular joint of idiopathic etiology, which begins before the age of twenty and as young as age eight years. This idiopathic etiology results in degenerative alterations to the growth zone of cartilage that lies immediately below the articulating collagen layer of the condyle. Boering stated that these degenerative changes impair the gliding function of the affected TMJ. This impairment promotes derangement of the TMJ, which results in mechanical insult to the mandible's subarticular growth site, causing diminished mandibular ascending ramus height, pronounced antegonial notching, and posterior inclination of the condylar process with flattening of

This report describes a case of acquired unilateral condylar hypoplasia that closely resembles the criteria for juvenile degenerative arthritis.

the affected condyle.[1] Early evaluation of ramus height and morphology by direct measurement and panoramic radiograph may be, therefore, an important consideration in determining early signs of future TMJ problems. This report describes a case of acquired unilateral condylar hypoplasia that closely resembles the criteria for juvenile degenerative arthritis.

CASE PRESENTATION

A healthy, twenty-eight-year-old Caucasian female (MS) presented at the University of Florida Dental Occlusion and Facial Pain Center for evaluation. Her chief complaint was left-sided intermittent clicking of the TMJ associated with intermittent moderate-to-severe headache. She stated that she had continuous clicking for a duration of eight years; in the last twelve months, however, the clicking has become intermittent, occurring once or twice a week.

As early as age fifteen, she had sought treatment for headaches from her family physician without relief. At age nineteen, MS became aware of headaches upon awakening in the morning. She stated that aspirin would totally relieve the headache. If she did not take aspirin the headache would stay for days. Approximately one headache per month would not respond to the aspirin. These headaches continued through age twenty-two. Orthodontic therapy was begun at age twenty-two and throughout treatment her head pain was severe. Upon the termination of orthodontic therapy, the severe headaches were reduced to moderate pain. MS found that Tylenol gave excellent relief from these headaches. She continued to experience mild-to-moderate headaches three to four days per week, up to age twenty-five. Tylenol continued to give excellent relief for this pain. At age twenty-six, she noticed that these headaches were directly related to stress and clenching. Presently, mild headaches occur one to two days per week, for which Ibuprofen gives moderate to excellent relief. MS denied symptoms to migraine pain, numbness associated with discomfort, allergies to substances, smoking, consuming alcohol, involvement in any accident or trauma to her head or neck and having any ear problems. She stated that she was never diagnosed as having arthritis and admitted to being aware of a slight facial asymmetry.

The dental history began at age eight, when alloy restorations were placed on the occlusal surfaces of the permanent molars. Additional restorations were placed periodically through age eighteen. Initial treatment for crowding included the removal of the lower left central incisor at age twelve and the removal of the third molars at age sixteen. At age twenty-two orthodontic therapy, preceded by extraction of the maxillary first premolars, was begun. No complications during or after any of the extractions were reported. At age twenty-four, orthodontic treatment was terminated. One week after having the orthodontic bands removed, her orthodontist performed an occlusal adjustment. Four more occlusal adjustments followed in the next two years by her general dentist.

On initial evaluation in the pain center, an oral pathology screening examination revealed normal findings. A joint laxity examination revealed excessive laxity in the left wrist and left elbow. A TMJ palpation examination elicited no discomfort. A TMJ auscultation examination via stethoscope disclosed bilateral reciprocal clicking with hysteresis. A mandibular range of motion examination revealed normal findings:

- ☐ Maximum vertical opening at 50 mm.
- ☐ Maximum right lateral excursion at 12 mm.
- ☐ Maximum left lateral excursion at 10 mm.
- ☐ Maximum protrusion at 10 mm, all without pain.

No mandibular deviation was noted at maximum opening of her mouth. Bilateral palpation of the carotid, facial, and superficial temporal arteries elicited no significant discomfort. A masticatory and cervical muscle palpation examination elicited no significant discomfort. Upon questioning, MS admitted to nocturnal and diurnal bruxing and clenching. Examination of her dental arch relationship revealed an Angle Class II malocclusion. Moderate wear facets slightly into the dentin were noted on the maxillary and mandibular incisors and severe wear facets deep into the dentin were noted on the maxillary and mandibular canines. Tooth mobility and percussion response were normal. No crossbite was present, possibly due to orthodontic correction. The mesial surface of the mandibular right central incisor was 2 mm to the left of the midline, possibly due to the extraction of the mandibular left central incisor, orthodontic therapy and left-sided condylar hypoplasia. The maxillary and mandibular right first premolars contacted prematurely in the centric relation closure arc, creating a right deflection of 0.75 mm and a vertical deflection of 0.5 mm in the slide from centric relation to maximum intercuspation position. No interferences were noted in mandibular crossover position. Group function occurred in right lateral and left lateral excursions. An anterior open bite of approximately 2 mm was revealed. This open bite involved the twelve anterior teeth only, causing the first 2 mm of right and left lateral guidance to be on the posterior teeth. Protrusive guidance was provided by the maxillary and mandibular left second premolars in the first 1.5 mm

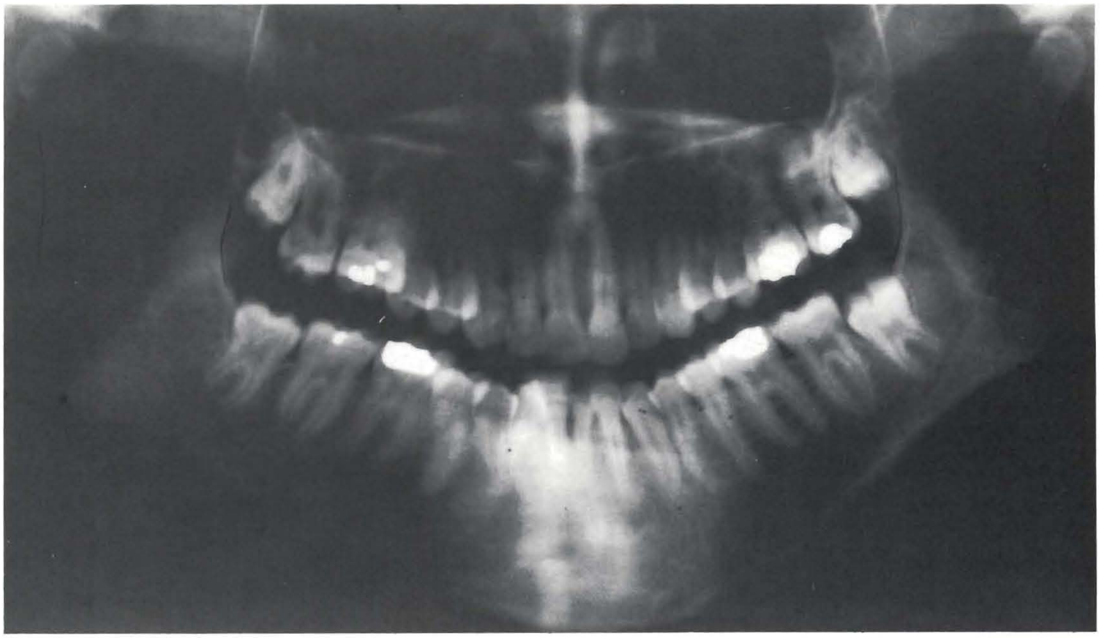

Figure 1. 1978 panoramic radiograph (age eighteen).

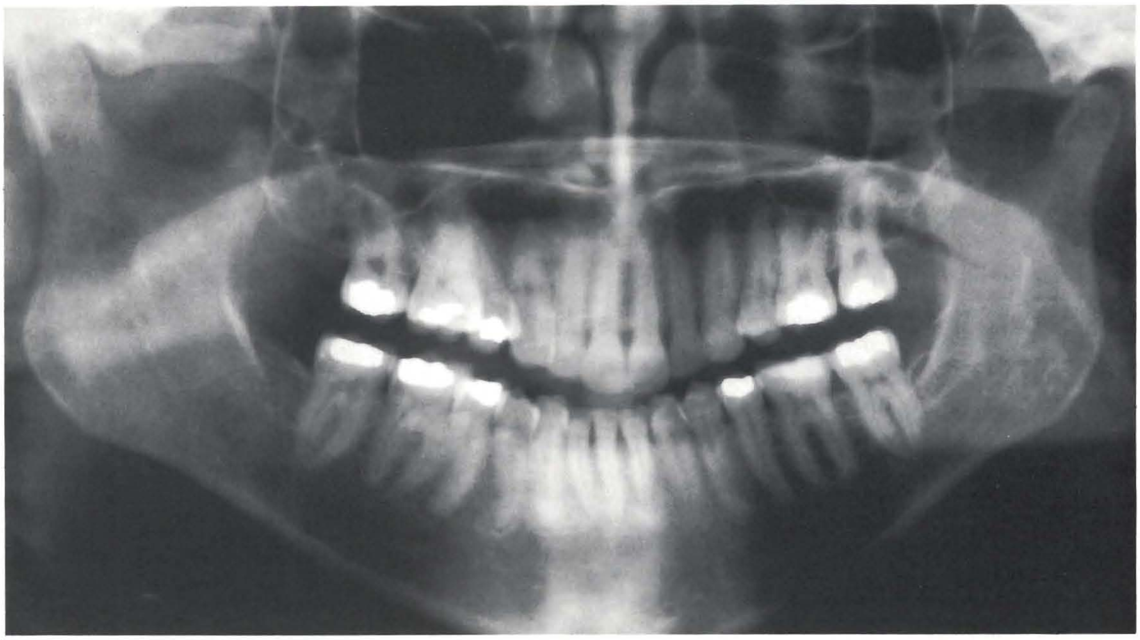

Figure 2. 1988 panoramic radiograph (age twenty-eight).

of movement, then a smooth transition to the incisors occurred. Direct measurements of ramus height were taken by palpating and marking the lateral lip of the glenoid fossa and the most inferior point on the inferior border of the mandible distal to the antegonial notch. Measuring between these points produced a condylar height measurement of 67 mm on the right side and 54 mm on the left side.

Radiographic evaluation was based on a lateral transcranial radiograph taken on the date of the examination and panoramic radiographs taken on 1978, at age eighteen, and 1988, at age twenty-eight (Figures 1 and 2). The lateral transcranial radiograph showed good cortication of the lateral aspect of the condyle and articular eminence in the left TMJ. Concentric condylar placement and moderate flattening of the left condyle was noted. Good bony morphology, good cortication of the lateral aspect of the condyle, and concentric condylar placement within the glenoid fossa were noted in the right TMJ. A panoramic radiograph dated August 1978 (Figure 1), at age eighteen, revealed an anteroposterior maximum width of 12 mm for the right condyle and an anteroposterior width of 33 mm for the right ramus. Radiographic ramus height, the distance measured from

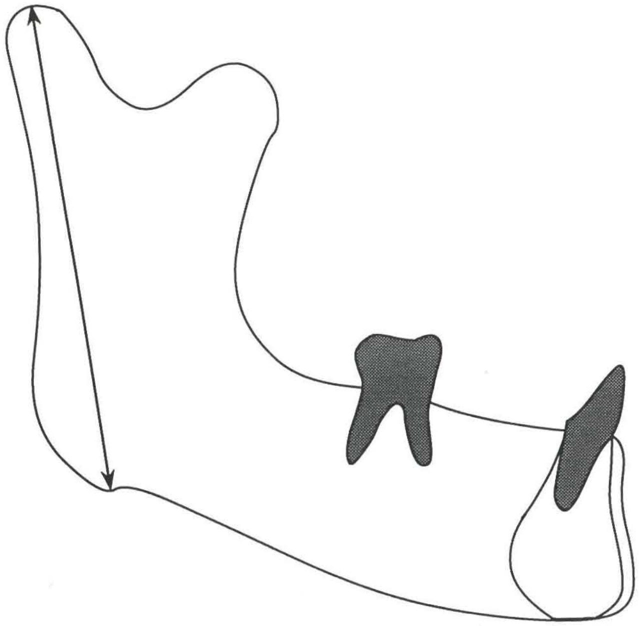

Figure 3. Diagnosis of asymmetries (measure the vertical distance along each ramus from the most inferior point on the inferior border of the mandible distal to the antegonial notch to the most superior point on the condyle).

the most inferior point on the inferior border of the mandible distal to the antegonial notch to the most superior point on the surface of the condyle (Figure 3), was 69 mm on the right. Maximum left condyle anteroposterior width was 11 mm, maximum left ramus anteroposterior width was 28 mm, and left ramus height was 64 mm (Table). A panoramic radiograph dated February 1988 (Figure 2), at age twenty-eight, revealed maximum anteroposterior width of 14 mm for the right condyle, maximum anteroposterior width of 34 mm for the right ramus, and right ramus height of 73 mm. Maximum left condyle anteroposterior width was 10 mm, maximum left ramus anteroposterior width was 26 mm, and left ramus height was 66 mm.

The panoramic radiograph dated 1978 revealed that the left condylar height was 5 mm less than the right condylar height. The 1988 panoramic radiograph (Figure 2) revealed that the left condylar height was 7 mm less than the right condylar height, whereas direct measurement of ramus height resulted in a ramus height difference of 13 mm. Comparison of the 1988 measurements (radiographic) to direct measurements of ramus height illustrated the distortion of the panoramic radiograph.[6] When there is facial asymmetry, the distances of bony landmarks to the film on the two sides seemed to amplify the ramus height of the short side much more than the contralateral side (Table). This reduced the radiographic difference between the two rami. It is likely that the radiographic measurements taken in 1978, therefore, also underestimate the difference in ramus height. Overall the affected left condyle was diminished in size; the bony morphology, however, showed no flattening or other signs of a degenerative process on the earlier panoramic radiograph.

The differential diagnosis was right-sided condylar hyperplasia, left-sided condylar hypoplasia, and left-sided juvenile degenerative arthritis. Condylar hyperplasia was ruled out, due to the overall diminished size of the mandible compared to the maxilla. Juvenile degenerative arthritis was ruled out, due to lack of evidence of any flattening or bony remodeling of the ipsilateral condyle seen in the 1978 panoramic radiograph, leaving acquired condylar hypoplasia with secondary development of degenerative arthritis as the diagnosis.

Treatment recommendations were as follows:

- ☐ To fabricate an occlusal, full-coverage, hard acrylic splint in centric relation with immediate posterior disclusion in all excursions for night-time use.
- ☐ To maintain a softer diet by selecting foods such as fish, chicken, and steamed vegetables and avoiding tough foods such as red meats, crisp fresh vegetables, tough breads, and hard nuts.
- ☐ To avoid wide opening of the mouth.
- ☐ To use an interval timer for twenty-one days. This timer is set to beep every fifteen minutes reminding her of clenching and bruxing of the teeth. During future times of stress or increased discomfort, MS was instructed to repeat the use of this timer for reducing habitual diurnal bruxing or clenching.

Table ☐ Comparison of panoramic measurements taken ten years apart and direct measurements taken at the time of the second panoramic film.

	Radiographic measurement (mm)				Direct measurement (mm)	
	Age 18		Age 28		Age 28	
	Right	Left	Right	Left	Right	Left
Condylar width	12	11	14	10		
Ramus width	33	28	34	26		
Ramus height	69	64	73	66	67	54
	diff. = 5mm		diff. = 7mm		diff. = 13mm	

DISCUSSION

Unexplained TMJ problems in children and adolescents have previously been considered very rare.[5] A significant number of adult histories, however, now revealed TMJ symptoms during childhood and adolescence.[1,2] Early detection is especially important since active mandibular growth in childhood and early adolescence may be diminished by TMJ inflammation, due to its effect on the mandibular subarticular growth site.[1]

Recommended screening steps for the routine evaluation of childhood and adolescent patients includes questions in the patient's history for facial asymmetry, TMJ noises, TMJ pain, headaches, limited mandibular opening, or masticatory muscle pain. The clinical examination should include TMJ palpation, TMJ auscultation, measurement of mandibular range of motion, masticatory muscle examination, occlusal function examination, and direct measurements of ramus height, when asymmetry is suspected. The occlusal function examination will reveal unilateral or bilateral crossbite or malalignment of the teeth that may occur as they respond to the developing mandibular asymmetry. In the presence of a positive response to at least one of these questions or abnormal data collected from these examinations a panoramic radiograph is indicated.

Distortions of measurements on the mandible in panoramic radiographs occur due to complex asymmetric magnification factors.[6] The panoramic radiographs are used to identify differences in morphology, such as unilateral antegonial notching, angulation of condylar neck relative to the posterior border of ramus, and shape of the condyle and coronoid process. Asymmetry of ramus height can be measured directly by marking the lateral lip of the glenoid fossa located by forceful palpation and measuring with a large caliper to the inferior border of the mandible, posterior to the antegonial notch.

When a mandibular asymmetry, a lateral deviating occlusal slide, and a growing mandible are present, reversible occlusal treatment is indicated. A nondirective occlusal splint will allow the masticatory muscles to position the condyles in their most physiologic position in the fossa. For children and adolescents, treatment considerations include nondirective occlusal composite overlays on posterior teeth for obtaining a balanced occlusion in the centric relation position or treatment position. This composite overlay therapy is an attempt to reduce further functional stress to the condyles and to decrease pain until mandibular growth is complete. As long as continued mandibular growth occurs, occlusal reevaluations every six months and annual panoramic radiographs are indicated. Once the occlusion no longer needs adjusting in a minimum period of six months and radiographic evidence supports completed mandibular growth, usually by the early twenties, the asymmetry can then be corrected by orthognathic/orthodontic treatment.

Unexplained TMJ problems in children and adolescents have previously been considered very rare.

The juvenile form of TMJ arthrosis as described by Boering is characterized by pain and limited movement in a period of rapid condylar growth. Boering stated that extra-articular pain in the temporal and parietal regions is probably referred pain from the TMJ; MS's headaches encountered during mid-adolescence were, therefore, possibly initial signs of TMJ disturbances.[1] If these TMJ disturbances affected the mandibular subarticular growth site, then this case could be classified as juvenile degenerative arthritis. A definite diagnosis of juvenile degenerative arthritis cannot be made in this case, because MS's history at age eighteen is not complete enough to determine whether there was diminished translation of the left condyle with joint degenerative changes. A degenerative process evidenced by arthrosis in the affected joint was not seen in the 1978 panoramic radiograph. Although initial awareness of clicking did not begin until a few years later, the early indication of head pain during growing years is compatible with asymmetrical mandibular alterations occurring before the onset of clicking. Additional indications of early TMJ alterations are evidenced by asymmetric morphology of the rami and condylar processes on the first panoramic radiograph taken at age eighteen. In this panoramic radiograph a discrepancy of 5 mm was found between the right (unaffected) side and the left (affected) side. As noted in the 1988 panoramic film, this measurement is probably grossly underestimated. In order for this discrepancy to occur, disturbances of the TMJ would likely have begun several years earlier. These findings support the need for diagnosis of TMJ symptoms or headaches in childhood and early adolescence.

SUMMARY

Evaluation for signs and symptoms of TMJ disturbances during childhood and early adolescence is important. Early occlusal treatment for mandibular asymmetries may reduce temporomandibular joint growth site pathofunction, thus resulting in less pain, headache, and asymmetrical development of the mandible.

REFERENCES

1. Boering, G.: Arthrosis deformans van het kaakgewricht. Leiden: Staflew en Tholen, 1966.
2. Toller, P.A.: Osteoarthrosis of the Mandibular Condyle. Brit Dent J, 134:223-231, March 1973.
3. Shafer, W.G.; Hine, M.K.; Levy, B.M.: *A Textbook of Oral Pathology*. 4th edition, Philadelphia: W.B. Saunders Company, 1983, pp 702-703.
4. Laskin, D.M.L Surgery of the Temporomandibular Joint. In: *Temporomandibular Joint Problems*, Solberg, W.K. and Clark, G.T., eds., Chicago: Quintessence, 1980, pp 111-127.
5. Dibbets, J.M.H.; Van der Wheele, L. Th.; Uildriks, A.K.J.: Symptoms of TMJ dysfunction: Indicators of growth patterns? J Pedo, 9:265-284, Summer 1985.
6. Langland, O.E.; Langlais, R.P.; McDavid, W.D. *et al*: *Panoramic Radiology*. 2nd Edition, Philadelphia: Lea and Febiger, 1989, p 102.
7. Dibbets, J.M.H.; Van der Wheele, L. Th.; Boering, G.: Craniofacial Morphology and Temporomandibular Joint Dysfunction in Children. In: *Developmental Aspects of Temporomandibular Joint Disorders*, Carlson, D.S.; McNamarra, J.A.; Ribbens, K.A., eds. Ann Arbor: University of Michigan, 1985, pp 151-182.

SLOW-RELEASE FLUORIDE RESIN AND ENAMEL UPTAKE

Potentially, the slow-release boron trifluoride resin material offers the opportunity for not only preventive but also restorative applications. The success of fluoride incorporated into restorative materials has been clearly demonstrated in the past by the use of silicate cements as anterior esthetic restorations [Forsten and Paunio, 1972]. Although silicate cements were known to have suboptimal physical properties, the silicate restorations transferred considerable amounts of fluoride to the tooth structure immediately adjacent to the filling and resulted in a low occurrence of secondary caries [Wilson and Batchelar, 1967]. Because of this clinical success, extensive efforts have been directed toward the development of dental materials which have the ability to effectively transfer fluoride to the adjacent tooth structure [Stamm, 1985]. The slow-release boron trifluoride BIS-GMA resin material is particularly promising as a restorative vehicle for long-term release of fluoride. Previous laboratory studies [O'Connell and Kwam, 1988] have demonstrated that this material provides the advantages of both fluoride availability and compatibility with composites. Potential applications for the slow-release boron trifluoride BIS-GMA resin material include the use as a bonding agent or restorative liner for anterior and posterior composite restorations and root surface restorations, a pit and fissure sealant material, and an orthodontic bonding resin.

Capilouto, M.L. *et al*: In vivo study of slow-release fluoride resin and enamel uptake. Caries Res, 24:441–445, December 1990.

Bilateral birooted maxillary primary canines: report of two cases

Mario E. Saravia, DDS, MEd

Primary canines with bifurcated roots are an extremely rare dental anomaly. According to Jones and Hazelrigg, only six cases have been reported since 1975 including theirs.[1] Of these, only one involved the maxillary and mandibular canines; all other cases were limited to the maxillary canines.[2-6]

Although etiology of this condition in unknown, it has been suggested that it may be the result of an ingrowth of tissue from Hertwig's epithelial root sheath.[4] It should be noted that in all recently published reports all cases are of a bilateral nature. The purpose of this article is to add a report of two cases to the existing literature of this very rare dental condition.

REPORT OF CASE 1

A four-year-six-month-old black male presented to a dental clinic operated by the VCU/MCV School of Dentistry for a routine initial examination. Intraoral examination revealed a full complement of primary teeth in good Class I occlusion. No caries was noted clinically. There was no recorded dental history and the medical history was noncontributory. X-ray examina-

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Figure 1. Bifurcated right maxillary primary canine, Case 1.

Figure 3. Bifurcated right maxillary primary canine, Case 2.

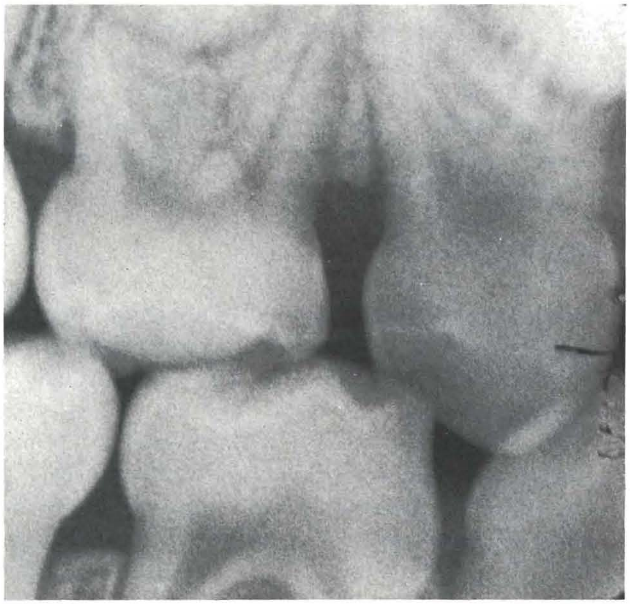

Figure 4. Bifurcated left maxillary primary canine, Case 2.

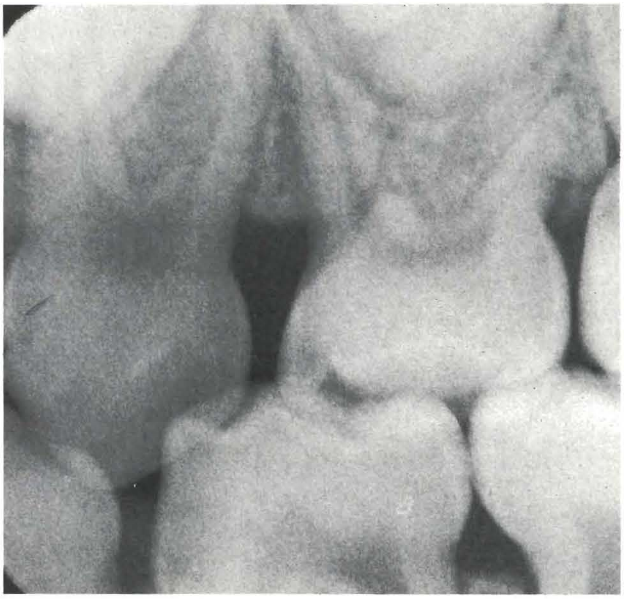

Figure 2. Bifurcated left maxillary primary canine, Case 1.

tion was within normal limits, with the notable exception of bifurcation of both maxillary primary canines (Figures 1,2).

REPORT OF CASE 2

The second case was discovered as an incidental finding while doing a radiographic survey for an unrelated research project. At the time of the initial visit, the patient, a four-year-old black male, presented with linguoclusal decay of tooth J (upper left primary second molar). The medical history was noncontributory and all other dental findings were unremarkable with the exception of bilateral primary canine root bifurcations (Figures 3,4).

As stated previously, bifurcation of primary canines is an extremely rare condition. This anomaly cannot be discovered by routine intraoral examination. It can often be detected, however, by examination of routine dental radiographs.

REFERENCES

1. Jones, J.E. and Hazelrigg, C.O.: Birooted primary canines. Oral Surg, Oral Med, Oral Pathol, 4:499-500, April 1987.
2. Bryant, R.H. and Bowers, D.F.: Four birooted primary canines: report of case. J Dent Child, 49:441-442, November-December 1982.
3. Brown, C.K.: Bilateral bifurcation of the maxillary deciduous cuspids. Oral Surg, Oral Med, Oral Pathol, 40:817, December 1975.
4. Kelly, J.R.: Birooted primary canines. Oral Surg, Oral Med, Oral Pathol, 46:872, December 1978.
5. Kroll, S.O. and Donahue, A.H.: Double rooted maxillary primary canines. Oral Surg, Oral Med, Oral Pathol, 49:374, April 1980.
6. Bimstein, E. and Bystrom, E.G.: Birooted bilateral maxillary primary canines. J Dent Child, 49:217-218, May-June 1982.

Oral lesion in an infant: congenital epulis or transformation to ameloblastic fibroma?

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Turgay Seçkin, DDS, PhD

The term *congenital epulis* was first used by Neumann in 1871 in describing a circumscribed soft-tissue mass on the gum pads of newborn infants.[1] The *ameloblastic fibroma* is an uncommon neoplasm of odontogenic origin that was probably first described by Kruse in 1891.[2-5] This tumor occurs in patients of the younger age-groups, generally between the ages of five to twenty-five years.[3-11] A few cases occurred in children younger than five years, as reported in the literature. The youngest patients were six, eighteen and twenty-two months of age.[3,4] Because the origin of granular cells in the *congenital epulis* has not been clearly resolved, a classification of *congenital epulis* could not be established.

REPORT OF CASE

In November 1987, a twenty-four-month-old white girl was brought to the pedodontic clinic by parents who first observed a mass in the child's mouth in the days immediately following birth. The parents did not report it to the physician, until discomfort and bleeding while feeding prompted them to do so; the child was twenty-four months old. On examination, the patient was found to have a soft swelling attached to the crest of the left maxillary ridge (Figure 1). No other anomalies were observed. The mass was excised using a local anesthetic and submitted for histologic examination. The preoperative diagnosis was congenital epulis. The lesion was ovoid and had a smooth surface, measured about 1.5 x 1 x 1 cm. Histologically the lesion consisted of a dense mesenchymal connective tissue that resembled the stroma of an ameloblastic fibroma. Numerous blood vessels were observed throughout the tumor (Figure 2), in addition to a few small islands of odontogenic epithelium in a mesenchymal component (Figures 3 and 4). The mass was without epithelial covering. The diagnosis was *congenital epulis*, probably *incipient ameloblastic fibroma*.

DISCUSSION

The *congenital epulis* is an uncommon lesion that occurs only on the gingiva of newborn infants, especially on the maxillary alveolar mucosa (4:1) and usually in females (8-10:1).[9,12-15]

The lesion appears as a protuberant mass, sometimes pedunculated.[16] It grows slowly and sometimes asymptomatically.[9,17] Microscopic examination shows the congenital epulis to consist mainly of large granular cells in a layered pattern.[9,13] Some fusiform cells similar to fibroblasts are interwoven with the large granular cells.[9,13,17-20] The stroma of the lesion was very vascular showing a prominent capillary net-

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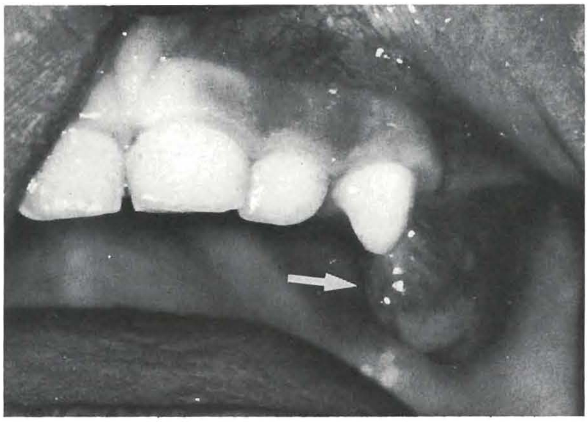

Figure 1. The lesion appears as a polypoid mass (arrow) on the maxillary ridge of a twenty-four-month-old girl.

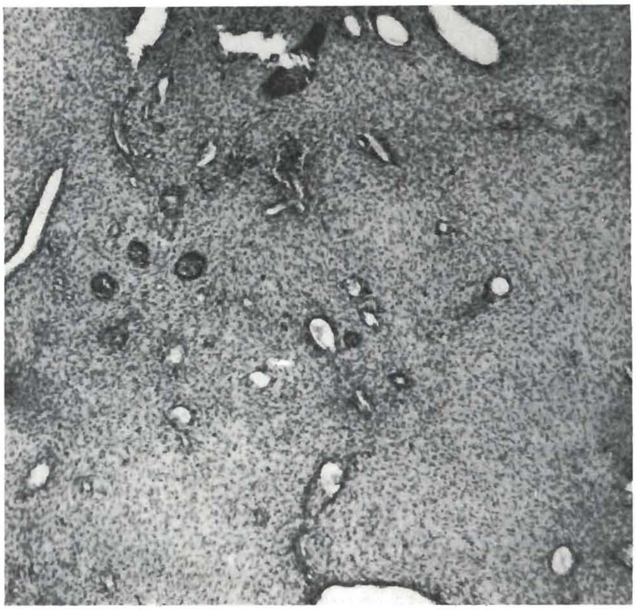

Figure 2. Low-power photomicrograph of the specimen showing a lesion composed of highly vascular fibrous connective tissue with a few round islands of odontogenic epithelium. (Hematoxylin and eosin stain. Magnification x 40).

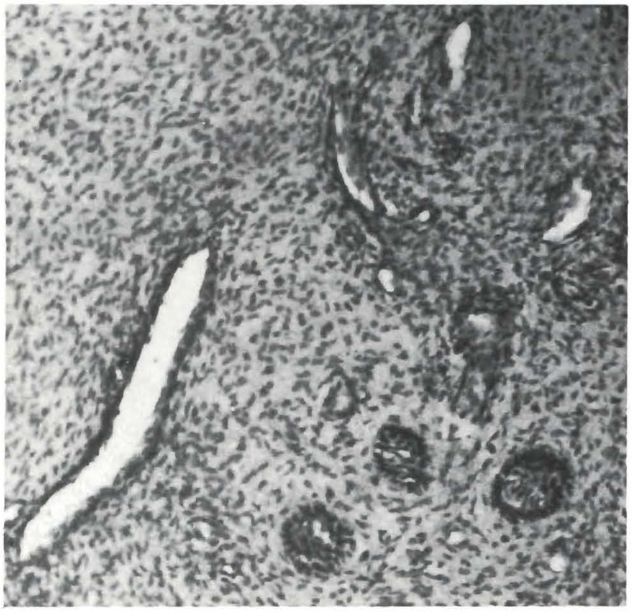

Figure 3. A high-power view of section shown in Figure 2. (Hematoxylin and eosin stain. Magnification x 90).

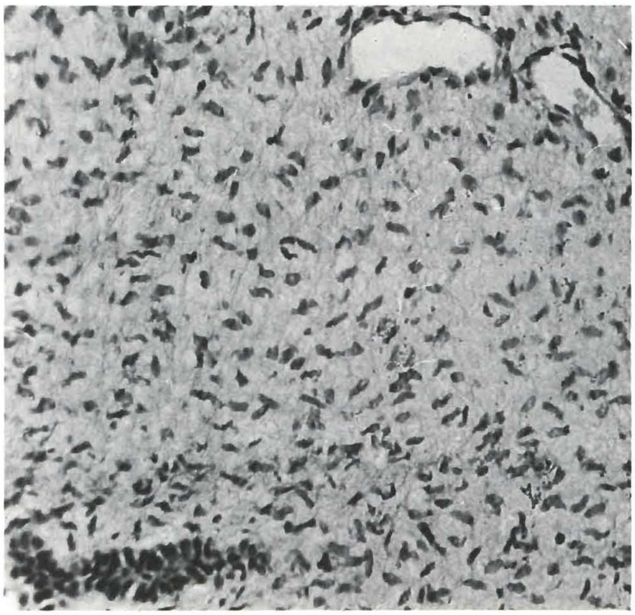

Figure 4. A high-power view of section showing delicate cords of odontogenic epithelium lying within the cellular connective tissue that resembles the stroma of an ameloblastic fibroma. (Hematoxylin and eosin stain. Magnification x 110).

work.[12,15,20,21] Scattered islands of odontogenic epithelium may be seen. The surface epithelium of the lesion is always atrophic.[9,13]

Ameloblastic fibroma does not infiltrate between bone trabeculae, but extends into bone as a solid mass.[9-11] Location of the lesion is only in the jaw bones. Radiologically, the tumor appears unilocular, as a well-defined cystic radiolucency; occasionally it will appear multilocular.[3,6,7,11] Unerupted teeth may be present.[3,6,7,9] The majority of patients are children and the average age is fifteen years. Two out of three patients are male and the mandible is involved more frequently than the maxilla (9:1).[9] *Ameloblastic fibroma* is characterized by proliferation of both epithelial and mesenchymal elements without formation of hard dental tissue.[4,5,10] Microscopically, the ectodermal component consists of scattered islands of epithelial cells in a variety of patterns, showing buds, cords, islands, and long finger-like strands.[10] These epithelial cells are usually columnar shaped. The finger-like strands of columnar epithelial cells resemble the dental lamina.[4,5] The mesenchymal component is made up of a highly cellular connective tissue that closely resembles the dental papilla.[10] There is a paucity of blood vessels in the stroma of the *ameloblastic fibroma*.[2,10]

If the lesion presented here were a true congenital epulis, some light could be shed on the origin of the granular cells. There are no published reports, however, of a congenital epulis left in the mouth for two years.

This lesion was more likely a congenital epulis, because it was located in the maxillary gingiva and the patient was a female infant. The mass was a smooth-surfaced, soft-tissue growth on the gingiva, but did not affect the jaw bone. The lesion was a slow growing mass that could remain on the gingiva for twenty-four months. Microscopically, there were no granular cells, but a few delicate strands and round islands of odontogenic epithelium in a matrix of connective tissue that resembles the stroma of an ameloblastic fibroma or dental papilla. These delicate strands and buds did not resemble odontogenic epithelium in an ameloblastic fibroma, but were similar to those found in a congenital epulis. In addition, the cell-rich mesenchymal tissue was well vascularized, as in a congenital epulis.

It is possible that all the granular cells in this lesion underwent transformation to fibroblast-like cells in two years. Some authors supported the theory of fibroblastic origin, because of the identification of some fibroblast-like cells among the granular cells in the congenital epulis, which are thought to be transformed into granular cells.[18,19] Some others have suggested the possibility of a change from a perivascular fibroblast or pericyte, because this lesion has an extensive blood supply and granular cells are closely adherent to the blood vessels.[15,21]

These fibroblast-like cells in the stroma of an ameloblastic fibroma and similar to the fusiform cells in the stroma of an ameloblastic fibroma and to the dental papilla. They are both odontogenic mesenchyma. It seems likely, therefore, that these fibroblast-like cells originated from the odontogenic mesenchyma. If the fusiform cells in this case have been transformed from granular cells, it would support the hypothesis that granular cells originate from odontogenic mesenchyma.

We tend to think that granular cells might have been transformed into fibroblast-like cells of the odontogenic mesenchyma. There is also proof of the transformation between the two cells: evidence that shows fibroblast-like cells changing into granular cells. There are published reports of a few ameloblastic fibroma cases that contain granular cells.[22-25] Although Waldron *et al* considered their cases to be granular cell ameloblastic fibroma they were probably related to the congenital epulis.[23] Also these authors suggested that the granular cells of these lesions seemed to be of mesenchymal origin. In addition, White *et al* consider the granular cells in these kinds of lesions to be mesenchymal in origin.[25]

Couch *et al* in 1962 were the first authors to point out a similarity between congenital epulis and granular cell ameloblastic fibroma.[22] They suggested the granular cell ameloblastic fibroma to be a manifestation in adults of the same developmental disorder that leads to the formation of congenital epulis of the newborn. Furthermore, they hypothesized that this abnormality is manifested in the dental papilla of primary teeth, by a polypoid lesion on the gum pads at birth. If this abnormality is derived from the dental papilla of the permanent teeth, the lesion will appear in the jaw bone as a granular-cell ameloblastic fibroma.

The *ameloblastic fibroma* occurs at younger ages.[3-11] Analyses of granular cell ameloblastic fibromas reported in the literature showed that all of the patients were older.[25] The transformation is the result of either maturation or degeneration and occurs over a period of several years. Waldron *et al* considered the transformation representative of an aging or degenerative change.[23]

Some authors supported an odontogenic origin for congenital epulis.[12,22,26] The odontogenic theory of origin has been propounded since the end of the last century.[13] Sunderland *et al* showed hypoplasia of the underlying teeth, following removal of a congenital epulis.[26] They suggested that the congenital epulis arises from odontogenic epithelium. This interesting finding highly supports the theory of odontogenic origin. In our opinion the origin of the granular cells in the congenital epulis is the odontogenic mesenchyma, but not the odontogenic epithelium. Pindborg and Clausen, who favored the induction theory of odontogenic tumors, believed that epithelium must once have been present to have effected the induction, but probably degenerated much as the dental lamina does in normal tooth development.[5] To initiate odontogenesis, odontogenic epithelium must be present. The same rule is valid for odontogenic tumors. Without odontogenic epithelium, odontogenic tumors cannot occur and without the induction of odontogenic epithelium, odontogenic mesenchyma cannot develop.[27]

Finally the *congenital epulis* and the *ameloblastic fibroma* should be closely related to each other and granular cells in the congenital epulis are probably transformed from the odontogenic mesenchyma.

REFERENCES

1. Neumann, E.: Ein Fall von congenital epulis. Arch Heilkd, 12:189-190, 1871.
2. Nilsen, R. and Magnusson, B.C.: Ameloblastic fibroma. Int J Oral Surg, 8:370-374, 1979.
3. Young, A.H.: Ameloblastic fibroma in an infant. J Oral Maxillofac Surg, 43:289-292, April 1985.
4. Gorlin, R.J.; Meskin, L.H.; Brodey, R.: Odontogenic tumors in man and animals: Pathological classification and clinical behavior, a review. NY Acad Sci Ann, 108:722-771, November 1963.
5. Gorlin, R.J.: Odontogenic tumors. In: *Thomas Oral Pathology*, Gorlin, R.J.; Goldman, H.M., eds. Ed. 6, St. Louis: The C.V. Mosby Co., 1970, pp 493-496.
6. Pindborg, J.J. and Hjørting-Hansen, E.: Atlas of diseases of the jaws. Philadelphia: W.B. Saunders, 1974, p 88.
7. Lucas, R.B.: *Pathology of tumors of the oral tissues*. Ed. 3, Edinburgh: Churchill Livingstone, 1976, pp 76-78, 116-118.
8. Batsakis, J.G.: *Tumors of the head and neck, clinical and pathological considerations*. Ed. 2. Baltimore: Williams-Wilkins, 1979, p 538.
9. Bhaskar, S.N.: *Synopsis of oral pathology*. Ed. 4. St. Louis: The C.V. Mosby Co., 1981, pp 273-276, 523.
10. Shafer, W.G.; Hine, M.K.; Levy, B.M.: *A Textbook of oral pathology*. Philadelphia: W.B. Saunders, 1983, pp 304-306.
11. Novince, W.M. and Grau, W.H.: Ameloblastic fibroma. J Oral Surg, 35:150-152, February 1977.
12. Custer, R.P. and Fust, J.A.: Congenital epulis. Am J Clin Path, 2:1044-1053, 1952.
13. Fuhr, A.H. and Krogh, P.H.J.: Congenital epulis of the newborn: Centennial review of the literature and a report of case. J Oral Surg, 30:30-35, January 1972.
14. Regezi, J.A.: Batsakis, J.G.; Courtney, R.M.: Granular cell tumors of the head and neck. J Oral Surg, 37:402-406, June 1979.
15. Rohrer, M.D. and Young, S.K.: Congenital epulis (gingival granular cell tumor): Ultrastructural evidence of origin from pericytes. Oral Surg, 53:56-62, January 1982.
16. Birman, E.G.; Lopes, R.A.; Barbosa, J.: Congenital epulis. Oral Surg, 34:437-439, September 1972.
17. Firfer, H.S. and Stuteville, O.H.: The congenital epulis. Oral Surg, 15:781-784, July 1962.
18. Bauer, W.H. and Bauer, J.D.: The so-called congenital epulis. Oral Surg, 6:1065-1071, 1953.
19. Bhaskar, S.N. and Akamine, R.: Congenital epulis. J Oral Surg, 8:517-523, 1955.
20. Dixter, C.T.; Konstat, M.S.; Giunta, J.L. *et al*: Congenital granular cell tumor of alveolar ridge and tongue. Report of two cases. Oral Surg, 40:270-277, August 1975.
21. Blair, A.E. and Edwards, D.M.: Congenital epulis of the newborn. Oral Surg, 43:687-691, May 1977.
22. Couch, R.D.; Morris, E.E.; Vellics, F.: Granular cell ameloblastic fibroma. Report of 2 cases in adults, with observations on its similarity to congenital epulis. Am J Clin Pathol, 37:398-404, April 1962.
23. Waldron, C.A.; Thompson, C.W.; Conner, W.A.: Granular cell ameloblastic fibroma. Oral Surg, 16:1202-1213, October 1963.
24. Regezi, J.A.; Kerr, D.A.; Courtney, R.M.: Odontogenic tumors: analysis of 706 cases. J Oral Surg, 36:771-778, October 1978.
25. White, D.K.; Chen, S.Y.; Hartman, K.S. *et al*: Central granular cell tumor of the jaws (The so-called granular-cell ameloblastic fibroma). Oral Surg, 45:396-405, March 1978.
26. Sunderland, R.; Sunderland, E.P.; Smith, C.J.: Hypoplasia following congenital epulis. Br Dent J, 157:353, November 1984.
27. Tahsinoğlu, M.: Odontogenic tumors. J Dent Fac Istanbul, 14:87-99, June 1980.

AMELOBLASTIC FIBROMA AND AMELOBLASTIC FIBRO-ODONTOMA

These two lesions are considered together because they appear to be variations of the same process. The occurrence of an odontoma(s) is characteristic of the ameloblastic fibro-odontoma; otherwise, the two lesions share similar features of age, gender, and location. Their biologic behaviors are also similar. Both are mixed odontogenic tumors composed of neoplastic epithelium and mesenchyme with microscopically identical soft tissue components. Both are regarded as benign neoplastic processes of odontogenic origin.

Clinical Features. These neoplasms occur predominantly in children and young adults. The mean age is about twelve years, and the upper age limit may extend as high as forty years. The mandibular molar-ramus area is the favored location for these lesions, although any region may be affected. There is no gender predilection.

Radiographically, these lesions are well circumscribed and are usually surrounded by a sclerotic margin. They may be either unilocular or multilocular and may be associated with the crown of an impacted tooth. An opaque focus appears within the ameloblastic fibro-odontoma owing to the presence of an odontoma. This lesion presents as a combined lucent-opaque lesion; the ameloblastic fibroma is completely lucent radiographically.

In *Oral Pathology*, edited by Regezi, J.H. and Sciubba, J.J.
Philadelphia: W.B. Saunders Company, 1989, p 364.

ABSTRACTS

Rohr, Max; Makinson, Owen, F.; Burrow, Michael F.: Pits and fissures: morphology. J Dent Child, 58:97-103, March-April 1991.
The morphology of fissures occlusally was examined by splitting teeth along fissures; this split occurred from the base of the fissure and was checked by serial sectioning. The conclusion is that fissures tend to be an association of adjacent pits. Staining of teeth for fissure shape determination indicates a high presence of organic material in fissures and pits with stained pellicle between pits. The pellicle is often very evident on the lower inclines of cusps, in the region where retention is sought for sealants. In a second phase, an examination of a large number of extracted molars showed that the occlusal fissure extension buccally in lower molars and lingually in upper molars was nearly always interrupted by an enamel col between adjacent cusps. Grooves occlusally or axially adjacent to fissures are often surfaced with stained pellicle. This may be mistaken on visual examination without magnification as extensions of fissures.
Pits and fissures; Teeth, human; Morphology; Grooves, developmental

Radcliffe, Richard M. and Cullen, Claire L.: Preservation of future options: restorative procedures on first permanent molars in children. J Dent Child, 58:104-108, March-April 1991.
Stainless steel crowns are indicted for permanent teeth for multiple reasons. Indirect or direct pulp capping, pulpotomies, apexification procedures, and root canal therapy are treatments for permanent teeth that make them potential candidates for stainless steel crowns as interim restorations. The transitional dentition is divided into two stages: between five and eight years; and the period between ages nine and thirteen. Mesiodistal dimensions of the first permanent molars can be measured on study casts before preparation for the steel crown has begun. A flow chart is provided to give practitioners available options. Steps for preparing the stainless steel crown and technique for porcelain onlay preparation are also given.
Crowns, stainless steel; Molars, first permanent; Dentition, mixed; Restorative procedures; Pedodontics

Kreulen, C.M. and van Amerongen, W.E.: Wear measurements in clinical studies of composite resin restorations in the posterior region: a review. J Dent Child, 58:109-123, March-April 1991.
During the last twenty years, wear-evaluation methods have changed, with newer techniques developed to determine the extent of loss of material in posterior composite resin restorations functioning in the mouth. These included: direct clinical evaluation; marginal evaluation on models; heights of exposed cavity walls; volumetric assessment of impressions; profilometry and artificial or natural references; section measurements; coordinate measuring device, contact and noncontact scanning; measuring microscope; photogrammetry; moiré topography; laser interferometry; scanning electron microscopy; and optical scanning. A laser scanning technique appears to hold great potential in clinical research.
Restorations, composite resin; Techniques, measurement; Wear

Straffon, Lloyd H.; Corpron, Richard L.; Bruner, Fred W.; Daprai, Fred: Twenty-four-month clinical trial of visible-light-activated cavity liner in young permanent teeth. J Dent Child, 58:124-128, March-April 1991.
A clinical study was performed to evaluate a new cavity liner, VLC- Dycal, on young permanent teeth for twenty-four months. One hundred fifty-two young permanent teeth were included in the study. Preoperative guidelines were followed and recorded with proper radiographs. Operative procedures were performed by dental staff and students as taught in the department. Three different specific methods of deep caries removal were tested and recorded: indirect pulp cap (IPC); direct pulp cap (DPC); and complete caries removal (CCR). The teeth were evaluated at six-month intervals for twenty- four months. At twenty-four months, 36 percent of the teeth (54 of 152) were evaluated. VLC-Dycal had a 91 percent success rate after twenty-four months. Only five teeth became devital, of which three were DPC and two were IPC. The data support the use of VLC-Dycal as an acceptable cavity liner.
Teeth, young permanent; Cavity liner; VLC-Dycal; Dentistry, operative; Pulp capping; Caries; Pediatric dentistry

Ben-Bassat, Yocheved; Brin, Flana; Fuks, Anna B.: Occlusal disturbances resulting from neglected submerged primary molars. J Dent Child, 58:129-133, March-April 1991.
Several studies indicated that submerged teeth have no long-term effect on occlusal development. Individual cases, however, may present extreme complications. Lack of close supervision, in such instances, may lead to serious consequences. Two cases of negligence (one on the parents' part and the other a consequence of the dentist's carelessness) are presented. The need for a close follow-up of submerged teeth is emphasized, and a rigid periodical recall schedule is suggested.
Pediatric dentistry; Occlusion; Infraclusion; Molars, primary, submerged; Examination, clinical, recall

Continued on page 88

ABSTRACTS *continued from page 86*

Gage, John P.; Symons, Anne L.; Romaniuk, Kornel; Daley, Terrance J.: Hereditary opalescent dentine: variation in expression. J Dent Child, 58:134-139, March-April 1991.
A family is described in which two females are more severely affected by hereditary opalescent dentine than the males. The genealogy of this family does not provide an accepted pattern of inheritance for this dentine anomaly. This may indicate that there is considerable variation in inheritance patterns for hereditary opalescent dentine and that this trait does not always exhibit 100 percent penetrance.
Dentine, hereditary opalescent; Dentinogenesis imperfecta; Teeth, primary; Dentistry, pediatric

Waldman, H. Barry: Do students in pediatric dentistry programs complete the course of training? J Dent Child, 58:140-143, March-April 1991.
Reviews by the ADA's Council on Dental Education have provided annual reports on many of the changes in enrollment and withdrawal from American dental schools, but little or no attention has been directed to withdrawal rates from postdoctoral education programs. We just do not know very much about the reasons why these advanced dental education students do not complete their courses of study.
Dental education, postdoctoral; Programs, pediatric dentistry; Attrition; Withdrawal

Waldman, H. Barry: There really are children in poor health. J Dent Child, 58:144-146, March-April 1991.
A report is provided on the general health status of children. Information is based on the latest National Health Interview Survey. In 1987, 1.8 million children were reported to be either in fair or poor health, contrary to prevailing stereotypes.
Children; Health; Demography; Income

Jerrell, Roy G.; Fuselier, Brian; Mahan, Parker: Acquired condylar hypoplasia: report of case. J Dent Child, 58:147-153, March-April 1991.
Temporomandibular joint (TMJ) problems in children and adolescents have been considered rare. This report describes the development of an acquired condylar hypoplasia first diagnosed in adulthood. It details the classification of condylar hypoplasia, Boering's arthrosis deformans juveniles and the inaccuracy of measurements taken on panoramic radiographs of patients with facial asymmetry. The patient presented with facial asymmetry, bilateral TMJ reciprocal clicking, history of diurnal and nocturnal bruxism, Class II malocclusion with anterior open bite, left condylar hypoplasia, right deflection of 0.7 mm in the slide from centric relation to maximum intercuspation and a thirteen-year history of headache. The initial treatment plan includes full-coverage, hard acrylic splint eliminating the lateral deviation in the slide; mechanically soft diet; avoiding wide opening of the mouth; and use of an interval timer to eliminate daytime clinching and bruxing. Early detection and occlusal treatment of TMJ disturbances in childhood and adolescence may reduce future growth problems at the TMJ.
Temporomandibular joint; Headache; Hypoplasia, condylar; Asymmetry, facial; Bruxism; Adults

Saravia, Mario E.: Bilateral birooted maxillary primary canines: report of two cases. J Dent Child, 58:154-155, March-April 1991.
X-ray examination disclosed bifurcation of both maxillary canine teeth in two unrelated patients, both four-year-old children. All other dental findings were unremarkable and their medical histories were noncontributory. Bifurcation of primary canines is an extremely rare condition.
Teeth, canine, bifurcated; Hertwig's epithelial root sheath; Radiographs, dental

NEWS

AMERICAN DENTAL ASSOCIATION STATEMENT ON DENTAL AMALGAM

Historically, dental caries has been the most widespread disease known to mankind. For over 150 years, dental amalgam has been the principal restorative material used to treat dental caries and restore patients to good oral health. As a result, many people today retain their natural dentition. Without the benefit of amalgam restorations, they would be partially or completely without their teeth. Throughout its use, there has been considerable scientific study of amalgam and no documented evidence to support the contention that amalgam, or the mercury contained in amalgam, has any deleterious effect on the health or physical well-being of the millions of patients served throughout the world.

The dental profession is committed to providing the best service to the public in a safe manner at a reasonable cost. At the present time, available alternative materials are either significantly more costly or have so far failed to demonstrate comparable strength, durability, or compatibility in the oral environment.

Banning dental amalgam would be financially advantageous to dental practitioners, since its replacement would necessitate the use of other, more costly materials and procedures. It also would be a disservice to those patients who would be denied the benefits of dental care because of prohibitive cost. Any replacement of existing amalgam restorations would be both costly and impose considerable risk to otherwise healthy teeth. The ADA thus continues to believe that dental amalgam should remain available as a safe and effective treatment.

The dental profession is committed to continuous improvement in the delivery of oral health care. During the past 50 to 75 years when dental caries was extremely common, massive amounts of amalgam were used to restore teeth. During the early years, the mercury-to-alloy ratio of amalgam was