Sequence and timing of bone augmentation and implant insertion for the adolescent patient: three case reports

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The use of endosseous osseointegrated implants to replace anterior missing single teeth is increasing. The high success rate, and the refining of surgical and prosthetic techniques, make it the first treatment of choice in many cases.[1,2] In adults the success of such implant-supported restorations depends mainly on the remaining volume and location of the bone. Moreover, placement of dental implants in the upper anterior segment is a technique-sensitive procedure, since an error in implant positioning can result in an esthetic failure. In many cases where bone is not available for ideal positioning of the implant, augmentation techniques are used. In the adolescent, in addition to these issues, developmental considerations are also important and must be weighed.[3–5]

Several problems occurring as a consequence of developmental processes are addressed in clinical reports. In early studies using ceramic implants the failure rate was high and increased when used in children younger than 11 years old.[6,7] Esthetic problems and implant fractures occurred frequently. However, since these were early generation implants, it is not clear to what extent the use of fragile ceramic materials and the surgical techniques contributed to the high failure rate reported, in addition to the clinical status of the young patients. In a later study following refining of osseointegration methods, Ledermann et al.[8] in their seven year follow-up, reported a 90% success rate. However, the shortcoming associated with the use of implants in children emerged. They described a shortening of implant-borne crowns, resulting from continued eruption of the adjacent natural teeth to their final positions, accompanied by cratering in the alveolar bone adjacent to the implants following eruption of the adjacent teeth. Shortening of the implant-borne crown was reported also by Johansson,[9] who placed an implant in a child aged 12 years and 3 months. As in the Ledermann study,[8] Johansson also noted, in a 4.5 year follow-up, substantial marginal bone loss where the implant had been inserted close to the tooth. Another drawback was described by Westwood[10] in a boy aged 15 years and 4 months in whom an implant was inserted to replace the congenitally missing maxillary left second premolar immediately after removal of the retained primary molar. A radiograph taken 48 months following implant placement revealed bone resorption due to skeletal growth in the floor of the antrum. The resorption exposed the apical end of the implant in the sinus.

There is no comprehensive protocol for the use of dental implants in young patients, although the developmental stage and implant location are considered the two critical factors in planning this treatment. As for the appropriate age, most of the reports[8,10,11] recommend to limit the treatment to children who are nearing or have already achieved complete alveolar bone growth. Bergendal et al.[12] add that only in rare cases of total aplasia, as in ectodermal dysplasia, should treatment with implants be advocated in childhood.[12] Johansson[9] suggested that with careful and optimal placement of the implant, taking into consideration further development of the jaws, implants can be inserted in growing adolescents. As for the location of the implant, Odman[13] and Thilander et al.,[14] on the basis of animal studies cautioned that implants not be placed posterior to the canines during active growth because of possible rotational growth that might leave the implant in a location other than the intended one.[15,16] In the anterior segment there is risk of implant submersion and lingual positioning after completion of development, because of the increase in bone height during pubertal growth. This holds true more for the maxilla than for the mandible.

An additional factor in the implant treatment plan is the availability of bone. Few authors refer to loss in alveolar bone in congenitally missing teeth and following trauma. Oster and Kokich[17] studied changes in ridge width over time in patients with congenitally missing mandibular second premolars, and found that ridge width decreased almost 30% during a period of

six years. Loss of alveolar bone following tooth avulsion or extraction is also common. The urgency to prevent bone resorption by immediate implant insertion following tooth loss is complicated by the risk involved in placing it in the growing alveolar bone. New and predictable bone augmentation techniques allow compensation for bone reduction while waiting for completion of growth.

Two approaches for obtaining bone augmentation around implants by guided bone regeneration are common. In the first, bone is regenerated simultaneously with implant placement. However, when initial stability of the implant cannot be achieved because of insufficient bone volume, a staged approach must be considered. Here the bone is augmented and later the implant is inserted. The first stage, the bone regeneration phase, may last between 8–10 months. The second, the implant integration period, may take an additional 6–8 months.

As the clinical decision when to start implant treatment is dependent not only on the timing of implant insertion, but also on bone regeneration procedures, all members of the team should be familiar with the sequence and timing of treatment. The following reports illustrate three clinical cases of missing teeth in young patients. The sequence and timing of bone augmentation and implant treatment are described.

Clinical Reports

Case 1-Implant placement where sufficient bone is diagnosed

A 16-year-old girl presented with a mobile maxillary right lateral incisor crown that was attached only by soft tissue. Five years earlier, the maxillary right lateral incisor and maxillary right central incisor were avulsed and subsequently replanted. A radiograph taken on examination (Fig 1A) revealed that the entire root surface of the lateral incisor was replaced by bone, leaving only root canal material. No radiolucent area was seen. A normal periodontal ligament space was evident on the distal aspect of the central incisor. On the mesial aspect, localized areas of surface resorption along the roots were observed. It was also evident that sufficient bone was available for an implant. Manual examination under local anesthesia,[18] revealed that the width of the alveolar bone was adequate for a narrow-sized implant. Considering the 5 years that had elapsed since replantation, the resorption on the central incisor was diagnosed as self-limiting. Treatment involved the placement of temporary crowns on the central incisor and lateral incisor as cantilever, followed upon termination of growth by an implant- supported single tooth restoration on the lateral incisor, and a ceramometal restoration on the central incisor. During surgical preparation of the implant bed, the gutta-percha was removed without perforation of the buccal bony plate, and an implant (Driskel Bioengineering, OH, USA) was inserted. Six months after insertion, at second surgery stage, the implant was exposed. A radiograph (Fig 1B) and clinical examination showed that integration had taken place, and the abutment was connected. Two separate crowns were then prepared (Fig 2). It is evident from the follow-up radiograph, taken 7.5 years later, that the location of the implant in relation to the adjacent teeth had not changed (Fig 1C).

Thus, there was no eruption of alveolar bone or teeth after implant insertion. The coronal part of the bone surrounding the implant neck revealed a bone loss of about 1 mm, which is considered a normal rate of resorption around implants.

In this case, the diagnosis was replacement resorption without inflammation. The available bone volume was adequate and as this kind of root resorption does not cause damage to the alveolar bone, implant treatment was begun upon cessation of growth.
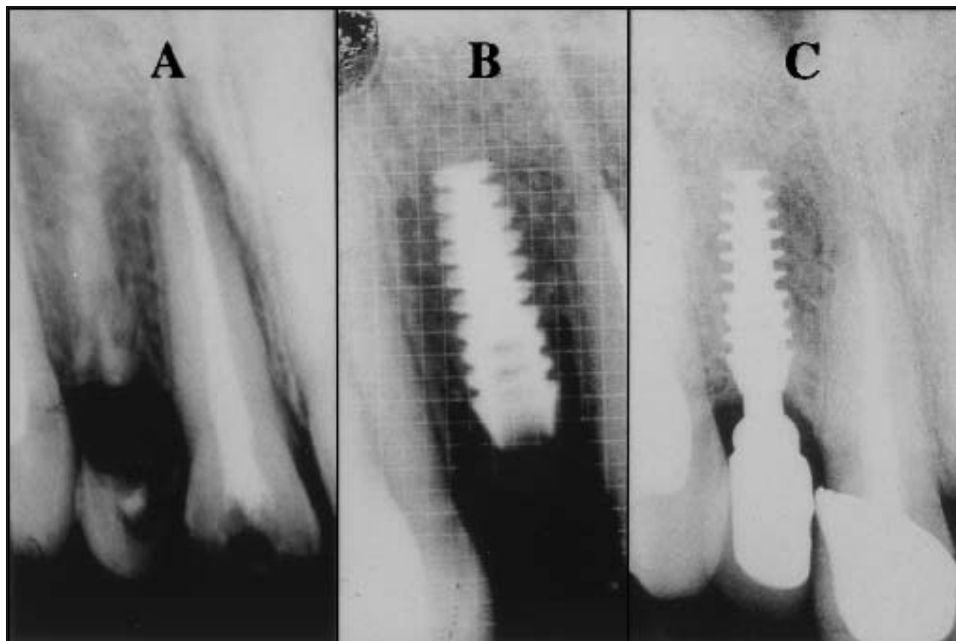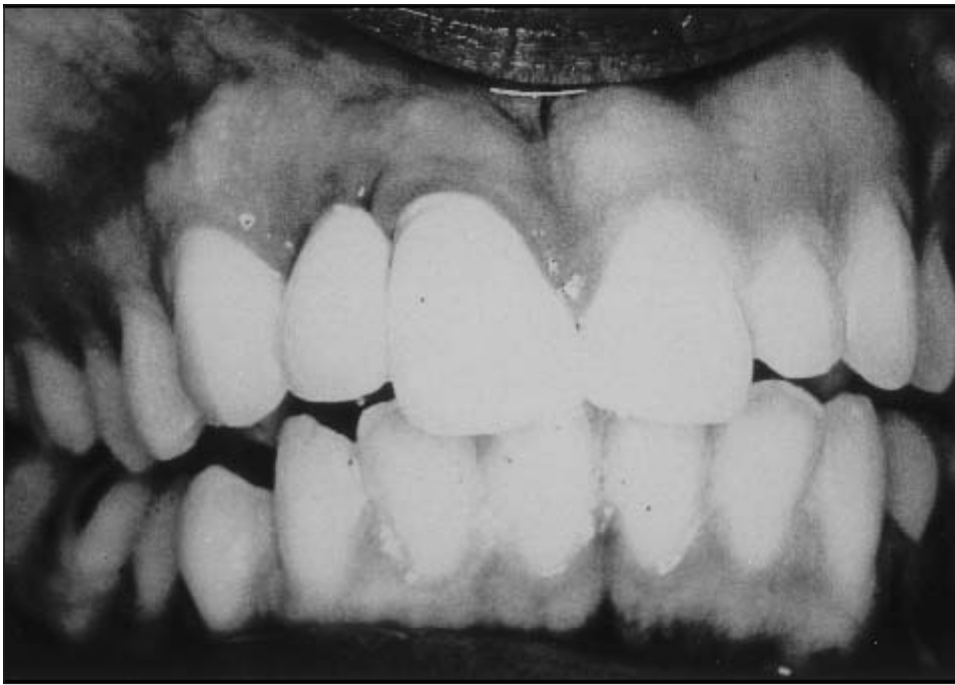

Fig 1A. Radiograph taken on examination, 5yrs following avultion and replantion. Fig 1B. Radiograph of the implant area 6 mos following insertion.   Fig 1C. A 7.5 year follow-up radiograph.

Fig 2. Case 1: Two separate ceramometal crowns supported by the maxillary right central incisor, and an implant replacing the lateral incisor.

In this case, the diagnosis was replacement resorption with inflammation. It was not clear if the inflammation had left a sufficient volume of bone for implant insertion. An additional diagnostic means, CT, was used to clarify whether a regenerative procedure was necessary. Examination revealed limited but sufficient bone volume and implant treatment was initiated after cessation of growth. If the CT had demonstrated insufficient bone volume, a regenerative procedure could have been started before cessation of growth, thus decreasing the time involved in the overall treatment by 8–10 months.

Case II—Implant placement where the amount of bone is in doubt

A 16.5-year-old girl presented with a mobile maxillary right central incisor. Clinical examination showed a fistula and inflammation of the soft tissue surrounding the tooth. Four years earlier, the central incisor was avulsed due to traumatic injury, and replanted. Since then attempts were made to resolve the inflammation by a series of root canal treatments. A radiograph revealed replacement resorption along the two sides of the root, as well as internal and inflammatory resorption (Fig 3A). The tooth was extracted (Fig 4A) and a removable partial denture was used as a temporary restoration. From manual examination of the bone, it was not clear if the bone width was sufficient to prevent dehiscence and to permit correct positioning of the implant. Three months following extraction, the future implant site was evaluated using computerized tomography (CT). A cross-sectional image (Fig 3B) demonstrated adequate width and length. However, the quality of the tissue at the extraction site was poor. After an additional three months, an implant (Mark II, Biocare, Goteborg, Sweden) was inserted. Ten months later, at second stage surgery, the implant was exposed. A radiograph and clinical examination showed that integration had occurred. The abutment was connected and a ceramometal crown was constructed (Fig 4B). A follow-up radiograph taken at the three years recall revealed that the integration was maintained without any changes in the relation between the implant and the adjacent teeth.

Case III—Implant placement requiring augmentation

A 15.5-year-old boy presented with a mobile maxillary left lateral incisor. Clinical examination showed inflamed soft tissue surrounding the tooth. Six months earlier the lateral incisor had been avulsed due to traumatic injury, and replanted. A periapical radiograph revealed severe bone loss around the tooth (Fig 5A).
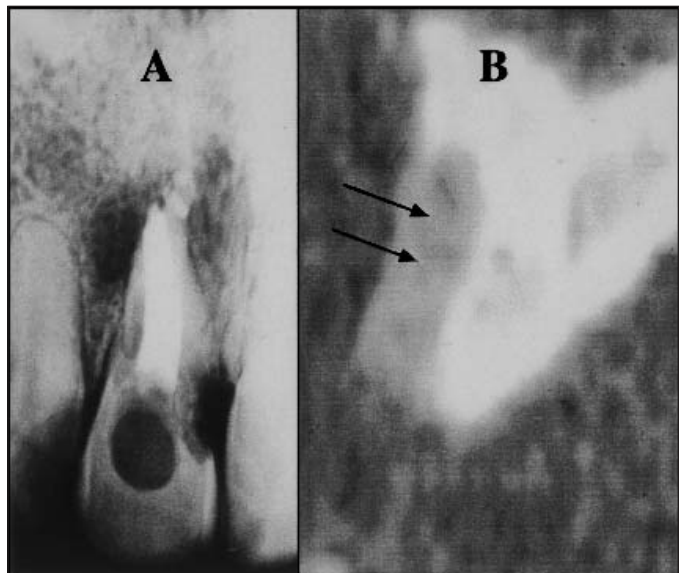
Fig 3A. Case 2: Radiograph taken 4 yrs following replantation.
Fig 3B. Cross-sectional image, obtained by reformatted computerized tomography, used to diagnose the available bone remaining after imflammation and extraction. The bone at the site of extraction site (arrows) is not yet mature.
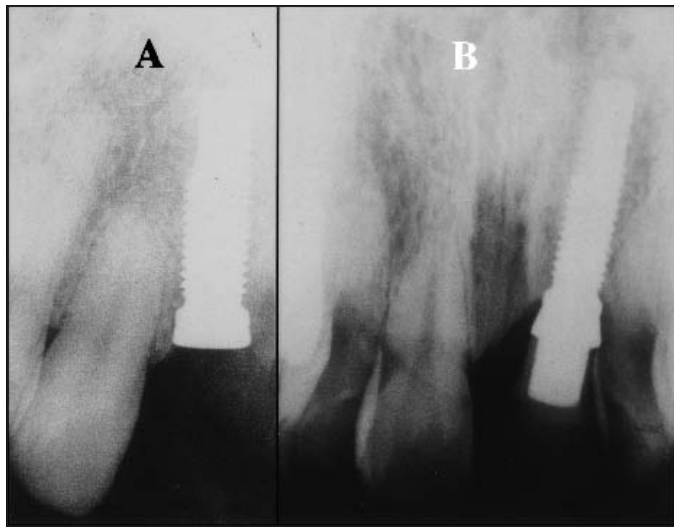
Fig 4A. Case 2: Radiograph taken 6 mos following implant insertion. The implant has integrated and there is no sign of previous pathology.
Fig 4B. A follow-up radiograph taken at the 3 year recall reveals that the integration is maintained without any changes in the relation between the implant and the adjacent teeth.

Four weeks following extraction, oral examination showed that the soft and hard buccal tissues were depressed (Fig 6A); horizontal probing revealed that only a thin palatalplate remained. Two separate procedures were planned: a regenerative one, to be followed by implant insertion. On flap reflection, during the regenerative procedure, it was obvious that the buccal plate was missing (Fig 7A). An expanding polytetrafluoroethylene (e-PTFE) membrane (Gore-Tex WL Gore, Flagstaff, AZ, USA) and demineralized, freeze-dried bone (Pacific Coast Tissue Bank, CA, USA) were used to augment the bone. Healing was uneventful. Two weeks following surgery, a temporary partial denture was constructed. Ten months later, when a flap was raised and the membrane was removed, it was evident that hard tissue had filled

the previous gap. A screw-type implant was then inserted (Biocare, Gotenborg, Sweden) (Fig 7B). Clinical and radiographic examinations revealed that the implant was integrated (Fig 5B) and a ceramometal crown was constructed (Fig 6B). A follow-up radiograph taken 2 years and 10 months following completion of the restoration revealed that the integration was maintained without any changes in the relation between the implant and adjacent teeth.

In the third case, clinical examination unequivocally demonstrated that the amount of bone loss would necessitate a regenerative procedure prior to implant insertion. This procedure was begun one year before cessation of growth, thus saving substantial time. This case demonstrates the importance of early referral for surgical evaluation.

Discussion

The restoration of edentulous areas in adolescents by means of implants may require bone augmentation prior to or simultaneous with implant insertion. The implant and augmentation sequence of treatment must be planned in light of the growth-associated process. Bergendal et al.[11] presented a flow chart of clinical considerations and decisions made from early diagnosis of multiple aplasia at 8 years to end of treatment at age.[18–19] They suggested to evaluate alveolar and facial growth as well as development and to start orthodontic treatment between 12–14 years. At the end of this period they recommended to evaluate the bone mass and quality in the edentulous area, followed at age 18–19 by further bone assessment by means of tomography in order to decide on prosthetic therapy and implant surgery. The ability to augment bone deficiencies by regenerative techniques requires additional considerations to be included in this flow chart. In cases in which the staged approach is

Fig 5A. Case 2: Clinical view of the right upper central incisor. The tooth was extracted in a 16.5-year-old girl, four years after replantation because of continuous inflammation.

Fig 5B. Implant-supported ceramometal restoration on maxillary right central incisor.
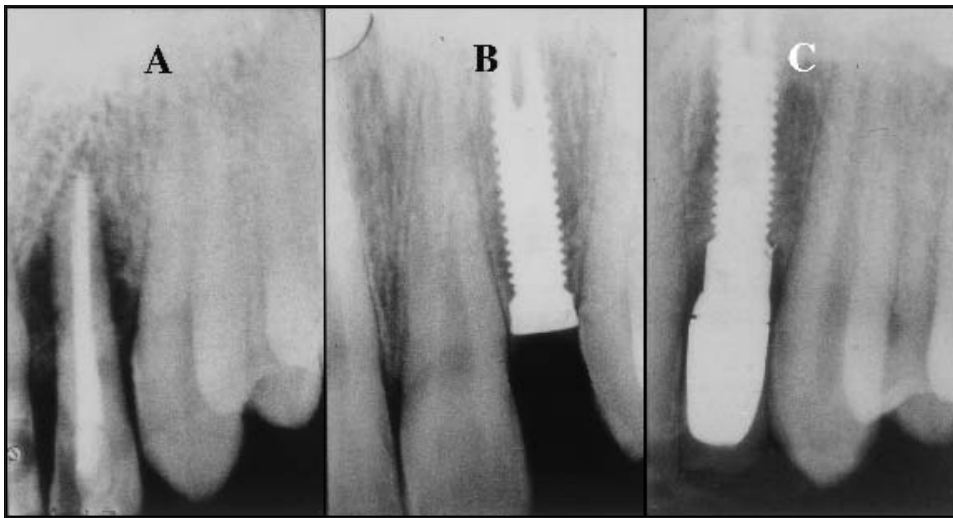
Fig 6A. Case 3: Periapical radiograph taken six months following replantation. Severe bone loss around the mazillary left lateral incisor is evident. Fig 6B. Radiograph taken six months following implant insertion. The implant has integrated. There is no sign of the previous pathology. Fig 6C. A follow-up radiograph taken 2 years and 10 months following completion of the restoration reveals that the integration is maintained without any changes in the relation between the implant and the adjacent teeth.

available: 1) if the amount of missing bone does not allow initial fixation, a staged approach is started and 2) if initial fixation of the implant can be obtained and augmentation is aimed to complete only small bone deficiencies, implant insertion and augmentation are postponed to the end of growth.

The effect of growth on the augmented bone is not quite clear and there is only a paucity of information concerning the use of bone regeneration procedures in growing patients.[19] This technique involves biological considerations other than implant treatment. An osseointegrated implant is expected to behave much like an ankylosed primary tooth, with the same lack of alveolar growth and dental eruption (i.e., to submerge into the alveolus). A regenerated or grafted site will probably demonstrate the same developmental pattern as the adjacent tissues. The third case confirms the value of the regeneration technique in the growing patient. In this case, a 15 year and 7 month old boy was treated using this technique for horizontal augmentation. Healing was not affected by the young age of the patient.

The issue of horizontal bone and vertical augmentation is also relevant when considering treatment. While several techniques[20–22] have been described for horizontal augmentation, with predictable results, supra-alveolar or vertical augmentation is difficult. The
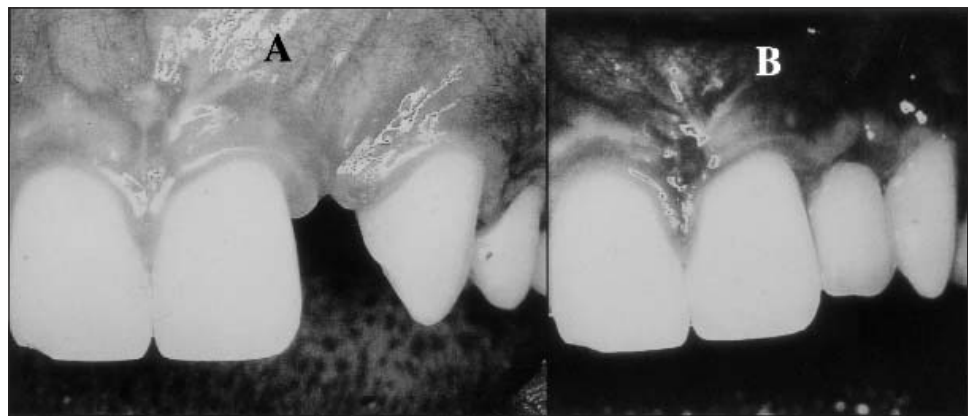
used, the overall treatment, consisting of bone augmentation (8–10 months), osseointegration following implant insertion (6–8 months), and the prosthetic phase (2–3 months) may last close to two years. Thus, when using this treatment modality, the time involved may be prolonged by 8–10 months. If treatment is begun at the end of growth, it will extend, including the use of temporary restorations, through a period when appearance is important to the patient. In many societies, the patients change their place of residence, which may complicate case management. It is, therefore, suggested to evaluate the bone volume about one year prior to the expected end of growth. In cases in which augmentation is indicated, this procedure may be performed a year before cessation of growth. Thus, the timing and sequence of treatment in augmentation cases should be started as Bergendal[11] suggested, at the age of 12–14 years, when a tentative prosthetic treatment plan is made, and orthodontic treatment is begun in accordance. About one year before cessation of growth, a clinical and tomographic evaluation is made. If sufficient bone is diagnosed, implant insertion can be carried out at a later stage, when growth is almost complete. In case of insufficient bone, two options are

Fig 7A. Case 3: Close view of the missing lateral incisor area. The soft and hard buccal tissues are depressed, indicating extent of bone loss. Fig 7B. Implant-supported ceramometal restoration on maxillary left lateral incisor.

few studies[23–25] that examined the potential of vertical bone regeneration suggested a limited natural potential for bone regeneration in supra-alveolar defects. The maximum new height achieved in a dog model was 2.2 mm. Use of demineralized bone materials in conduction of guided regeneration techniques is also of limited potential in inducing bone formation in vertical augmentations.[26] An additional method for vertical augmentation is autogenous bone grafting (from the iliac crest or from intraoral sites). This procedure is used mainly in severe atrophic jaws in adults,[27, 28] and there are no reports of its application in young patients. Extrapolations from successful treatment of cleft palate with early alveolar bone[29, 30] should be judicious. This is because the surgical technique and the healing aspects are different from those of vertical augmentation. In growing patients it is worthwhile to postpone augmentation to a time when most of the vertical growth of the treatment site and the adjacent teeth has already occurred (i.e., 8–10 months before the expected cessation of growth). This will provide good support for the membrane as well as a close source of osteogenic cells. This consideration is not valid in cases of congenitally missing teeth with wide edentulous areas, where the alveolar bone will probably not develop vertically.

It should be mentioned that implant insertion and the bone regeneration procedure can be carried out simultaneously, after cessation of growth. The advantage of this approach is the relatively short time involved. However, if primary stability of the implant cannot be achieved because of minimal bone volume, this technique is not feasible and augmentation should be performed separately. Moreover, if augmentation of the defect fails, the implant too is lost. Thus, in the growing patient, the staged approach permits better utilization of time, while waiting for cessation of growth for the implant insertion, thereby providing an overall better prognosis. In developing a comprehensive protocol for implant treatment in adolescents, the implications of the regenerative procedures should be considered.

Conclusions

When considering implant treatment in young patients, bone volume should be evaluated about one year prior to the estimated cessation of growth. If there is insufficient bone for initial stability of the implant, treatment should start with bone regeneration and continue with insertion of the implant near or at cessation of growth. This approach enables termination of treatment at an earlier age and improves implant prognosis.

References

1. Lany WR, Tortsen J, Harris D et al: Osseointegrated implants for single- tooth replacement: Progress report from a multicenter prospective study after 3 years. Int J Oral Maxillofac Implants 9:49–54, 1994.
2. Patrick D, Zosky R, Lubar R, Buchs A: The Longitudinal Clinical Efficacy of Core-vent Dental Implants in Partially Edentulous Patients: a 5-Year Report. In: Tissue integration in Oral, Orthopedic and Maxillofacial Reconstruction, Laney WR, Tolman DE, Eds. Chicago: Quintessence Publishing, pp 341–49., 1990.
3. Perrott DH, Sharma AB, Vargervik K: Endosseous implants for pediatric patients. Oral Maxillofac Surg Clin North Am 6:79–88, 1994.
4. Cronin RJ, Oesterle LJ, Ranly DM: Mandibular implants and the growing patient. Int J Oral Maxillofac Implants 9:55–62, 1994.
5. Oesterle LJ, Cronin RJ, Ranly DM: Maxillary implants and the growing patient. Int J Oral Maxillofac Implants 8:377–87, 1993.
6. Scholz F, díHoedt B: Der frontzahnverlust im jugendlichen gebiss-therapiemoglichkeiten durch Implantate. Dtsch Zahnarztl Z 39:416–24, 1984.
7. Frisch E, Pehrsson K, Engelke W, Sennhenn S, Jacobs HG: Beitrag zur problematic der implantation im oberkiefer-frontzahn bereich. Z Zahnarztl Implantol 6:108–110, 1990.
8. Ledermann PD, Hassell TM, Hefti AF: Osseointegrated dental implants as alternative therapy to bridge construction of orthodontics in young patients: Seven years of clinical experience. Pediatr Dent 15:327–33, 1993.
9. Johansson G, Palmqvist S, Svenson B: Effects of early placement of a single tooth implant. A case report. Clin Oral Impl Res 5:48–51, 1994.
10. Westwood RM, Ducan JM: Implants in adolescents: A literature review and case reports. Int J Oral Maxillofac Implants 11:750–55, 1996.
11. Bergendal B, Bergendal T, Hallonsten AL, Koch G, Kurol J, Kvint S: A multidisciplinary approach to oral rehabilitation with osseointegrated implants in children and adolescents with multiple aplasia. Eur J Orthod 18:119–29, 1996.
12. Bergendal T, Eckerdal O, Hallonsten AL, Koch G, Kurol J, Kvint S: Osseointegrated implants in the oral rehabilitation of a boy with ectodermal dysplasia : a case report. Int Dent J: 41:149–56, 1991.
13. Odman J, Crondahl K, Lekholm U, Thilander B: The effect of osseointegrated implants on the dento-alveolar development. A clinical and radiographic study in growing pigs. Eur J Orthod 13:279–86, 1991.
14. Thilander B, Odman J, Crondahl K, Lekholm U: Aspects on osseointegrated implants inserted in growing jaws. A biometric and radiographic study in the young pig. Eur J Orthod 14:99–109, 1992.
15. Bjork A, Skieller V: Growth of the maxilla in three dimensions as revealed radiographically by the implant method. Br J Orthod 4:53–64, 1977.
16. Bjork A: Prediction of mandibular growth rotation. Am J Orthodt 55:585–99, 1969.
17. Ostler MS, Kokich VG: Alveolar ridge changes in patients congenitally missing mandibular second premolars. J Prosthet Dent 71:144–49, 1994.
18. Wilson JW: Ridge mapping for determination of alveolar ridge width. Int J Oral Maxillofac Implants 4:41–43, 1989.
19. Zoolo ML, Ferreria MO: Ridge augmentation following extraction of replanted central incisor. Endod Dent Traumatol 10:94–97, 1994.
20. Buser D, Dula K, Hirt HP, Berthold H: Localized Ridge Augmentation using Guided Bone Regeneration in Implant

Dentistry. 1st Ed. Buser D, Ed. Chicago,Quintessence Publishing, pp 189–233, 1994.

21. Becker W, Becker BE, McGuire MK: Localized ridge augmentation using absorbable pins and e-PTFE barrier membranes: A new surgical technique. Case reports. Int J Periodont Res Dent 14:49–61, 1994.

22. Linde A, Thoren C, Dahlin C, Sandberg E: Creation of new bone by an osteopromotive membrane technique. J Oral Maxillofac Surg 51:892–97, 1993.

23. Jovanovic SA, Schenk RK, Orsini M, Kenney EB: Supracrestal bone formation around dental implants: An experimental dog study. Int J Oral Maxillofac Implants 10:23–31, 1995.

24. Simion M, Trisi P, Piattelli A: Vertical ridge augmentation using a membrane technique associated with osseointegrated implants. Int J Periodont Rest Dent 14:469–511, 1994.

25. Tinti C, Parma-Benfenati S, Polizzi G: Vertical ridge augmentation: What is the limit? Int J Periodont Rest Dent 16:221–29, 1996.

26. Caplanis N, Sigurdsson TJ, Rohrer MD, Wikesjo UME: Effect of allogeneic, freeze-dried, demineralized bone matrix on guided bone regeneration in supra-alveolar peri-implant defects in dogs. Int J Oral Maxillfac Implants 12:634–42, op 1997.

27. Tolman DE: Reconstructive procedures with endosseous implants in grafted bone: a review of the literature. Int J Oral Maxillofac Implants. 10:275–94, 1995.

28. Misch CM: Ridge augmentation using mandibular ramus bone grafts for the placement of dental implants: presentation of a technique. Pract Periodontics Aesthet Dent. 8:127–35, 1996.

29. Dado DV, Rosenstein SW, Alder ME, Kernahan DA: Long-term assessment of early alveolar bone grafts using three-dimensional computer-assisted tomography: a pilot study. Plast Reconstr Surg 99:1840–45, 1997.

30. Takahashi T, Fukuda M, Yamaguchi T, Kochi S: Use of endosseous implants for dental reconstruction of patients with grafted alveolar clefts. J Oral Maxillofac Surg 55:576–83, 1997.