

Chapter 26

Craniofacial growth in adults and its implications for implant reconstruction

Fereidoun Daftary DDS, MSD, Ramin Mahallati DDS, Oded Bahat BDS, MSD, FACD, and Richard M. Sullivan DDS

Introduction

Long-term observations have alerted the dental profession to complications that may occur when teeth and implants coexist and subtle adult craniofacial growth occurs [1]. For example, there have been reports of changes relative to patients' remaining teeth and jaw structures in partially edentulous patients reconstructed with implant restorations [1–15]. These changes, which appeared to be random deviations from expected implant-restorative stability and were difficult to explain, conformed to research findings of continued craniofacial growth into adulthood. Several areas have now been identified in which such adult craniofacial growth influences the relations of implant restorations to the remaining teeth and jaw structure [4, 7, 12, 14, 16–34],

Growth can be defined as an increase in size or dimension. Significant growth clearly begins with early fetal development and continues from birth through adolescence. These increases in size and complexity are obvious. The progressive growth of the skeletal structure slows as a person approaches adulthood, whereas body mass may continue to increase. Hair and nails continue to grow throughout life. Growth can also be defined as a process of restructuring and continued development and remodeling.

Craniofacial growth in adulthood has not been considered in implant treatment planning. Indeed, until recently, such growth has been absent as a topic in the dental implant literature, in part because these changes take variable periods of time, often many years, to become manifest [1, 2], whereas observation periods usually have been no more than a few years, allowing inadequate time for growth effects to become evident. If any craniofacial growth was noted, the effects were ignored or dismissed as artifacts. However, now that

there have been decades of posttreatment observation of single- and multiple-tooth implant restorations, it is becoming apparent that for some patients there are significant esthetic, functional, restorative, and periodontal ramifications of subtle continued growth [1–4, 7–10, 12, 14, 15, 35, 36]. The evident changes may include labialization of an anterior implant restoration and a progressive discrepancy of the cervical gingival margin of the restoration relative to the adjacent teeth [1–4, 7–15, 36–38]. Figures 26.1 and 26.2a, b illustrate long-term treatment outcomes being compromised as a result of growth occurring after it was believed that a stable jaw dimension had been reached. The predictors will be discussed in detail in the conclusions of this chapter.

When changes in tooth position relative to implant restorations occur secondary to adult growth, the restorations are compromised [2, 7–10, 15, 36, 38]. Modifications in surgical and restorative procedures are presented in this chapter that will increase the longevity of the results achieved with implant therapy. A secondary purpose



Fig. 26.1 Implant in position 7 showing labial and apical positioning of the implant in relation to the natural dentition.



Fig. 26.2 (a) Implant crown in position 8 immediately post cementation. (b) Implant in position 8 some 12 years post placement. Implant-supported restoration and the facial tissue has become more apical. The restoration is also slightly facial.

of this chapter is to encourage healthcare providers to inform prospective patients about the possibility that continued growth may compromise intraoral esthetics and function and require corrective action.

Etiology

Because of the rapid growth of young individuals, the effects of growth and remodeling can be studied in a short time. In young pigs, investigators replaced several teeth with dental implants. As the jaws grew, new teeth erupted more coronally and buccally [39], whereas the implants remained in the same three-dimensional spatial coordinates as the body developed around them [40]. Implants blocked further growth of the alveolar process and also altered tooth bud development in adjacent sites, causing deformation of the contiguous bud structures [41].

The human jaw behaves the same way [31]. For example, for 3 years, Thilander *et al.* followed 15 patients (mean age of 15 years, 4 months) with dental implants. Infra-occlusion of the restorations was apparent in the

patients who were still growing. Therefore, they concluded that the patients' dental maturation, not just chronological age, needs to be considered when placing implants [31]. When the same group of patients was followed for an additional 5 years, infra-occlusion of the restorations continued to increase even in the absence of skeletal growth [32]. This phenomenon was attributed to lack of incisal stability.

In 2004, Bernard compared the vertical changes in teeth adjacent to single-tooth implants in 14 young and 14 mature adults [3]. In a mean of 4.2 years (range 1 year 8 months to 9 years 1 month), similar changes occurred in both young and mature patients. Infra-occlusion of implant restorations in the anterior maxilla was found not to be confined to patients who were expected to have further growth.

Craniofacial changes and its effects on stability of occlusion in the adult patient are important aspects of orthodontics whether implants are present or not. Bis-hara and coworkers, who followed changes in the dental arches and dentition in adults between the ages of 25 and 45 years [23], recorded increasing vertical overlap, especially in female subjects, as well as a decrease in arch-length measurements, indicating crowding or mesial drift of teeth with aging.

Forsberg *et al.* examined the vertical craniofacial and dentoalveolar changes in 15 male and 15 female subjects between the ages of 25 and 45 years [27]. Anterior face height increased an average of 1.6 mm over the course of their study. The most significant increase (80%) was seen in the lower dentoalveolar region. Angular measurements revealed posterior mandibular rotation with uprighing of the maxillary incisors. A significant amount of eruption of the maxillary incisors and first molars was found in female subjects between the ages of 9 and 25 years [28]. Although the most significant eruption occurred during the adolescent years, the changes continued well into adulthood. In a 5-year longitudinal study of 151 Swedish dental students [29] initially between the ages of 21 and 26 years, the vertical and angular changes were strikingly similar to those seen by Forsberg *et al.* [27]. These authors found a 1.5 mm increase in facial height and an increase in the amount of vertical overlap, again showing uprighing of the maxillary incisors.

When differences in dentoalveolar heights were measured in three age groups [30], and the findings corroborated the results of previous longitudinal studies. Specifically, anterior dentoalveolar heights in both maxilla and mandible were significantly greater in the middle-aged and older subjects. On average, the maxillary ridge height increased more than that of the mandible. Also, the angle of the mandible increased with time, again indicating uprighing of the maxillary incisors.

Bondevik studied changes in occlusion in 144 Norwegian subjects between the ages of 23 and 34 years [25]. They noted an average increase in the intermolar distance, a decrease in the intercanine distance, and changes in the horizontal and vertical overlap. In two separate cross-sectional radiographic studies, Ainamo and coworkers concluded, perhaps surprisingly, that alveolar growth continues all the way to age 65 years [16, 17], with the width of the attached gingivae increasing significantly between the ages of 23 and 45 years. These increases continued to age 65, although at a slower rate. The dimension of the basal bone in the maxilla increased, but not in the mandible.

West and McNamara measured dental and craniofacial changes from adolescence to an average age of 48 years [34]. Their findings support the view that the maxillary teeth continue to erupt into adulthood. In male subjects, the incisors erupted only a small amount while maintaining their facial/palatal position, but in female subjects, the crowns tipped toward the palate as the incisors erupted. Male subjects showed anterior rotation of the mandible, whereas posterior rotation was more common in female subjects. In both sexes, maxillary molars erupted and moved toward the anterior during adulthood.

Clearly, subtle adult growth of dentoalveolar and facial structures is common and therefore must be taken into account in orthodontic planning. Unpredictable movement of the alveolar process resulting from adult craniofacial growth can present clinical challenges to implants and the restorations they support [1] (Fig. 26.3). There are numerous additional papers documenting changes in adulthood [2–4, 7–12, 14–25, 27, 29, 30, 33, 35–38, 42–44]. The growth does not involve the tissue immediately surrounding the implant, but rather the teeth, alveolar process, and soft tissue, either in the jaw containing the implant restoration or in the opposing site [39–41]. Such growth can cause the opposing jaws to migrate in different

directions. There are some differences between the sexes in the extent and direction of adult growth, adding to the complexity of treatment planning [7, 19, 21, 34].

Although craniofacial growth is well documented in adults, the clinical impact, which may range from subtle to substantial, is not well documented. A dental implant is a fixed three-dimensional spatial marker that forms a stable reference point from which to observe and measure craniofacial changes [45]. Unlike teeth and edentulous spaces in the alveolus, the implant is out of synch with any craniofacial movement, standing relatively stable as the adjacent landscape slowly shifts (except in the case of displacement growth in younger patients) [46]. Thus, when overall facial growth occurs, the implant and restoration do not move to accommodate the changes [39, 40]. The impact of subtle growth changes may be almost imperceptible on the adjacent dentition, but changes may also be significant, causing substantial esthetic and functional changes around the implant (Fig. 26.4) [7–10, 15, 36]. At this time, it is not possible to predict the changes, if any, that will happen in a particular patient, mandating close follow-up to detect them early [25].

A detailed literature review was made of adult orthodontic and forensic anthropologic studies of craniofacial changes over an adult lifetime, both overall trends and site-specific occurrences. The authors' clinical observations, radiographic, and photographic comparisons were used to identify long-term craniofacial changes. Adult craniofacial growth may influence the relation of implant restorations to the remaining teeth and jaw structure in several ways. These changes include alterations in occlusion due to anterior or posterior rotation of mandible and opening of the proximal contacts when implants and teeth coexist due to mesial migration of the teeth [7], alterations of soft tissue levels, and thickness due to continued eruption of the teeth and/or palatal movement of teeth and alveolar housing adjacent to the implant-supported restoration.



Fig. 26.3 Implant reconstruction 7 years post delivery showing extreme discrepancy in the alveolar growth.



Fig. 26.4 Implant-supported restorations in positions 10 and 11 demonstrating incisal discrepancy 4 years after insertion as well as loss of canine guidance.

Prevention and treatment

Modifications of techniques and treatments have been suggested on the basis of both the possibility and unpredictability of a significant esthetic or functional complication as a result of craniofacial changes. These treatment modifications aim to minimize the negative consequences of craniofacial growth on implant-supported restorations.

Surgical considerations

Reduction in tissue thickness

Often reduction in the thickness of the hard and soft tissue on the facial aspect of implants has been observed over time [2, 7, 9–11, 32]. One possible result is that an implant that was originally housed adequately in the bone displays thread exposure on the facial side (Fig. 26.5). Use of smaller implants and modification of the trajectory of the osteotomy may prevent or delay this problem. Because of changes caused by remodeling of the alveolar process, implant size and positioning become more critical (Fig. 26.6a, d, e). Use of the narrowest implant diameter that will satisfy the biomechanical demands while preserving the optimal

supporting position within the available bone should be considered, allowing a thicker facial plate as a starting point. However, the utility of a narrower implant should always be weighed against the risk of biomechanical overload and component failure. One option is to use two narrow implants rather than one in areas of high anticipated force, such as the molar region [47–51]. The objective is to achieve a balance between the diameter of the implant and the anticipated biomechanical load.

In the maxillary anterior region, implants should be placed more palatally, with an axial trajectory toward the cingulum rather than the incisal edge. Even if it is possible to place the implant in a reduced ridge, grafting of the facial aspect to conform to the contours of the adjacent dentition is recommended. In addition, soft tissue thickness can be increased with a connective tissue graft [52] (Fig. 26.7a, b). The challenge is not just adequate anchorage and appropriate local healing but also accommodating the possible future changes caused by growth. When a reduced volume of tissue is encountered or in patients in whom immediate placement is desired, bone and soft tissue augmentation should be considered (Figs. 26.6c–e and 26.7a, b).

Timing of implant placement

For both mandibular and maxillary situations, immediate implant placement into sockets with a thin alveolus or bone loss caused by destructive disease or trauma (e.g., root fracture) probably is not advisable. The challenge for the anterior implant restoration is adequate blending with the surrounding area [52].

When dental extraction is necessary for the maxillary anterior region, delayed implant placement provides an opportunity to evaluate the healed and maturing bone to obtain greater predictability in long-term esthetics with growth considerations, especially in higher risk patients. Immediate implant placement may be a less-than-optimal choice in patients with thin and diminished bone housing and those for whom the future dimensions of the ridge are not entirely clear. When the anterior tooth loss and immediate implant placement are the result of trauma, the unstable alveolus and the potential for healing can be evaluated more clearly after a healing period allows determination of tissue volume and stability. A delayed protocol involving an initial augmentation procedure, rebuilding the jaw to the prior anatomic situation (prior to the disease-induced changes) allows more precise evaluation prior to the second surgical entry for implant placement. This opportunity for further assessment of bone and soft tissue dimensions after completion of site augmentation and healing may indicate that further attempts at site recovery before or accompanying implant placement are necessary if deemed desirable to add volume, anticipating the potential for growth.



Fig. 26.5 (a) Implant-supported restoration in positions 10 after placement. (b) Implant supported restoration in position 10, 11 years post delivery, demonstrating tissue discoloration and thinning of the buccal mucosa.

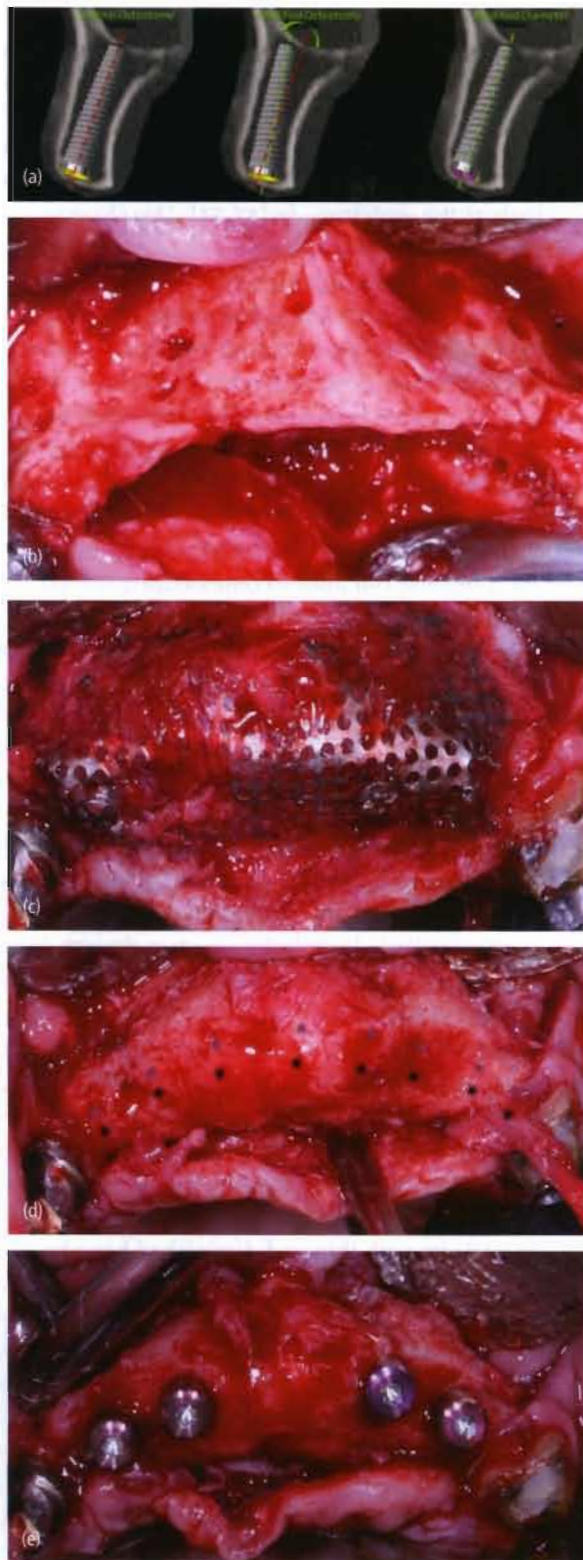


Fig. 26.6 (a) Anterior osteotomies should anticipate possible future craniofacial growth. (b) Severely resorbed maxillary anterior ridge. (c) Nine months later, the titanium mesh has been partially covered by fibrous tissue. (d) Implant placement planning. Conventional osteotomies would be created at the light blue entry points, but positioning the osteotomies at the darker marking sites will allow for increased facial bone. (e) Implants have been placed in the sites favoring increased facial bone.

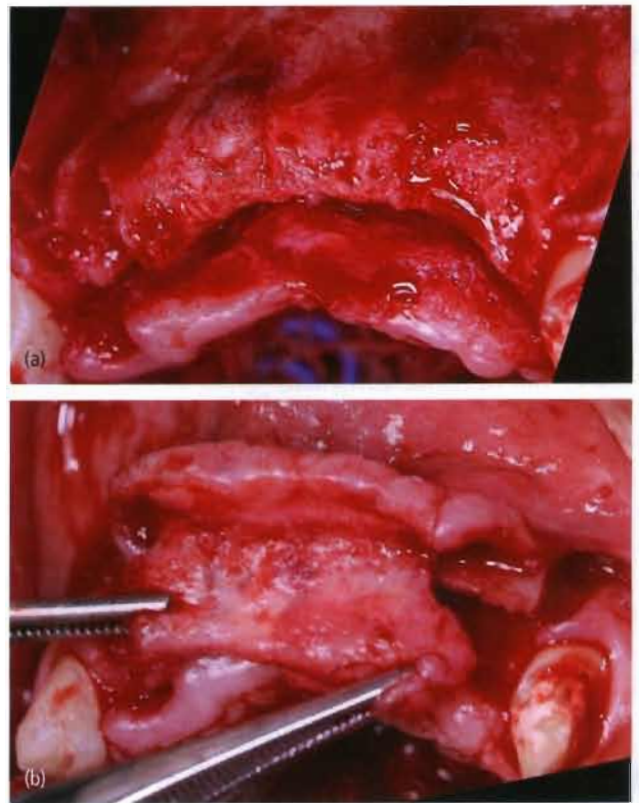


Fig. 26.7 (a) Increasing the soft tissue and bone volume in this severely resorbed maxillary ridge may reduce the impact of any future tissue changes subsequent to craniofacial growth and the aging process. (b) Flap was enhanced in thickness six weeks prior to surgery, thus anticipating the potential for growth.

Replacement of implant restoration

For patients who have already been treated, the downward and more vertical growth trajectory of the anterior maxilla can make the implant restoration appear to be too apical [8–11, 15, 32] (see Figs. 26.2a, b, 26.5a, b, and 26.8a, b). More importantly, when there is a high smile line, the cessation of alveolar growth at the implant site may create an uneven gingival line with reduced architecture and harmony. Simple replacement of the restoration may not correct these changes fully. If the compromise is sufficiently significant, removal of the implant and restoration of the site with hard and soft tissue grafting followed by implant placement and restoration may be necessary. Depending on the clinical situation, a segmental osteotomy to reposition the jaw segment containing the implant may be an alternative [53, 54] (Fig. 26.9a–c).

As the mandibular body grows or expands laterally, the jaw may grow away from the fixed position of the implants (Fig. 26.10a, b). When possible, implants should be placed more to the buccal to delay thread exposure



Fig. 26.8 (a) Implant supported restoration in position 7 shortly after delivery. (b) Restoration 20 years post delivery.

through the lingual cortex of bone (Fig. 26.11). For patients with congenitally missing posterior teeth, early implant restoration can offer obvious benefits. Because of the mesial migration of natural teeth and the stationary nature of the implant restoration, open contacts can be expected. Such single-tooth replacement can be expected to require some future modification to correct the expected mesial movement of the teeth and opening of a contact. Likewise, unilateral posterior multiple-unit implant restorations will not accommodate any three-dimensional changes of the contralateral and opposing natural teeth [31, 32, 39–41].

Restorative considerations

Undesirable alterations in esthetics and occlusion have been attributed to craniofacial growth. Some changes can be evaded by better surgical planning, as described above. Restorative planning, corrective modifications over time, or alternative treatment should also be considered. Tissue stability around all restorations, the implant-

supported structures in particular, is of paramount importance to the longevity of an attractive restoration. Thicker tissue is more stable and less prone to recession. Concave subgingival contours of the abutments can be considered in order to allow thicker tissue around the implant [55]. As practitioners, we go to great lengths to create a proper occlusal scheme for each individual patient. Maintaining occlusal stability over time is highly desirable to ensure the longevity of our restorations (Fig. 26.12a, b).

Some changes tend to be sex-specific and some related to the facial form [26, 30]. For example, female patients tend to have more pronounced uprighting of the anterior maxillary teeth and posterior rotation of the mandible, with the clinical crowns of the teeth moving more palatally relative to an implant restoration [8–10, 18, 27, 34, 56]. In men, on the other hand, the downward movement of maxillary teeth and soft tissue with less palatal movement of those structures is observed [34]. Male patients also tend to have more pronounced growth in the ramus and anterior rotation of the mandible [19, 24, 34]. In clinical situations where implant restorations oppose implant restorations in the posterior sextants, changes caused by anterior rotation of the mandible can result in loss of posterior support. Because the growth in the condyle is not a tooth-dependent phenomenon, this effect also can be observed in patients with completely implant-supported reconstructions. Such gradual changes affecting functional occlusion and posterior support underscore the importance of diligent occlusal monitoring and adjustments. Patients with long faces tend to have more vertical residual growth in the anterior region, causing more esthetic disharmony for the implant-supported restoration [7, 14]. Patients with round or short faces tend to have more transverse growth, causing more functional disharmony and accelerated wear in the posterior as the result of loss of guidance [57, 58]. When an anterior tooth (particularly a cuspid) is replaced by a dental implant, the lack of continued movement of the implant restoration may also result in undesirable changes such as loss of guidance and occlusal interferences in the posterior region [27, 30].

Meticulous monitoring of occlusion at all recall visits is encouraged. On discovery of such changes, corrective measures should be undertaken as soon as possible. These corrections can include occlusal adjustments, changing contours, and esthetic corrections through bonded restorations or replacement of the implant-supported restoration (Fig. 26.13a–c). Particularly in the posterior region, opening of the contacts anterior to the implant restoration may result from mesial migration of the natural dentition [7, 21, 23, 25, 34] (Fig. 26.14).



Fig. 26.9 Incisal edge discrepancy of implant restorations 9 and 10 has been corrected by segmental block (a–c) repositioning. Photograph provided by H. Zadeh. Reproduced with permission from H. Zadeh.



Fig. 26.10 (a) Implant restorations shortly after delivery. Gold crown no. 31 is tooth-supported restoration. Photograph provided by R. Yanase. Reproduced with permission from R. Yanase. (b) Tooth-supported restoration has migrated buccally due to craniofacial growth while implant restorations have stood still.



Fig. 26.11 Due to buccal apposition and lingual resorption of bone in the mandible, most distal implant displays most amount of thread exposure.



Fig. 26.12 Loss of cuspid guidance on the implant-supported restoration on teeth 10 and 11. Photographs provided by G. Bracchetti. Reproduced with permission from G. Bracchetti.

Given the potential changes in adjacent contacts, incisal length, and occlusion, both patient and dentist may benefit from the use of restorations that are more easily retrievable, such as screw-retained restorations. In the case of cement-retained restorations permanent cement should be avoided if possible (although with ceramic restorations, temporary cements may be contraindicated). Other design modifications, such as creation of a notch at the lingual margin combined with margin placement



Fig. 26.13 (a–c) Tooth 8 was prepared for veneer restoration to correct incisal edge discrepancy.

at or above the gingival line, might be beneficial to facilitate retrieval. An additional possibility is the use of an inclined lingual set screw, providing separating force to facilitate crown removal [59].

A practical challenge confronting clinicians is congenitally missing lateral incisors, a prevalent condition motivating treatment at a younger age. However, the unpredictable nature of correction of esthetic damage subsequent to growth should be clearly understood by both the dental professionals and the patients contemplating such treatment. For younger patients who have congenitally missing single teeth, high smile lines, or high esthetic demands, delaying implant placement using a



Fig. 26.14 Mesial migration of the natural teeth mesial to the implant-supported molar.



Fig. 26.15 (a) Missing maxillary left central incisor (b) Resin-bonded restoration is used as alternative to implant placement.

fixed resin-bonded restoration for an open-ended period may be a better option (Fig. 26.15a, b) [60].

Recommendations

Perhaps the most important procedure is a thorough discussion with patients at the beginning of treatment, followed by oral and written informed consent. All restorative dentists should have a policy regarding who is responsible for modification and remake fees and over what timeline. Specifically, the following question

should be addressed: Who will bear the responsibility for future treatment costs if modification or retreatment is required, not because of any failure of the implant site, component, or restoration, but rather because of growth of adjacent areas of the mouth or jaws that is significant enough to create either a functional or esthetic disharmonious relation between the implant restoration and the progressively growing host? Minor modification or repair of the restoration may not be possible for various reasons. Situations may develop in which restorations cannot be retrieved but must instead be remade. Also, restorations may become compromised in the process of repair, as when cracks or bubbles appear in the porcelain after placement in the oven for minor repair. This can require the porcelain to be stripped and reapplied; at worst, it will demand that the restoration(s) be completely remade.

In patients who present with risk factors such as a short or long face, youth, a high smile line, a short lip, or greater esthetic needs, pretreatment discussion can help prepare the patient for the possible need for and limitations of future corrective actions.

Early observation of any changes is important. In the posterior of both jaws, evaluation of the occlusion of the implant restoration relative to any teeth should be frequent and consistent. An aggressive recall system is essential to identify early signs of growth. When teeth and implant restorations coexist, the potential for changes in the adjacent and opposing dentition relative to implant restorations introduces a new dimension and concern for long-term occlusal management. The occlusion should be checked thoroughly at every recall visit and adjusted or corrected as appropriate. Patients should be examined for open or light contacts, and if any are found, they should be corrected. When changes resulting from growth are esthetically apparent, early surgical intervention should be suggested if this would be corrective. Correction of the jaw may require implant removal, socket grafting, vertical augmentation, or provisional restoration.

Still awaited are long-term outcomes favoring or arguing against implant placement at the time of tooth removal in the esthetic zone. The benefits and limitations of staged versus immediate approaches will continue to be evaluated on a case-by-case basis. The long-term goal should be maintaining sufficient labial tissue with minimal impact resulting from movement of the adjacent tooth, alveolar process, and soft tissue.

Acknowledging the lack of supporting documentation, an occlusal splint is highly recommended for mixed implant and tooth arches to act as a retainer and

minimize changes in tooth position. At the same time, the limitation of not knowing the effects relative to the jaw and facial growth is recognized.

Patient and clinicians should be aware that it is fallacious to assume that the initial esthetics and function of implant reconstructions will last without ever requiring modification or repair. Although lifelike restorations and living tissue may coexist in harmony, living tissue evolves and adapts. Continued adult craniofacial growth, including horizontal and vertical migration of the jaw structures and teeth, may cause intra- and inter-arch occlusal changes, intra-arch eruption height discrepancies, and interproximal contact changes.

When craniofacial or dental-alveolar growth contributes to functional occlusal or esthetic compromises, the required corrective actions may include restorative modification or replacement, invasive soft tissue and osseous procedures, and occasional implant removal and site reconstruction. Because of the possible limitations and impact of such corrective procedures, early identification of patients with known general risk factors for disruptive craniofacial growth is important prior to implant placement. Knowledge of known risk factors should be applied to plan future treatment and minimize negative impacts. Maintenance of implant patients' dental-alveolar harmony can be a dynamic process.

At present, it is not possible to predict with complete certainty who is at risk for disruptive adult craniofacial changes and to what extent. Planning of single-tooth replacement and partially edentulous arch configurations requires a case-by-case evaluation, including age, genetics, and countless combinations of inter- and intra-arch factors influencing tooth and implant structural support for dental restorations. If patients considering

treatment can be made aware that the subtly changing position of teeth, jaws, and other facial structures may require further treatment at additional expense, both the patients and the clinicians treating them benefit from this understanding.

Classification

Adult craniofacial growth after cessation of skeletal growth has been identified as the offending factor in spatial changes in some partially edentulous patients where dental implants have been used as a treatment modality. The types and vector of movement vary among patients. Some movements are more common in patients with certain facial forms while some are more biased to one gender. As of today there is no classification system for ease of reporting or communication among various dental professionals. A classification system inherently provides certain degree of logical grouping and potentially provides the organization necessary for pattern recognition, therefore the following classification is suggested.

- *Class I:* Apicocoronal discrepancy of the implant restoration and the natural teeth. Implant-supported restoration is more apical compared to natural dentition. This class of disharmony is more common in male patients and in the anterior sextant (Fig. 26.16).
- *Class II:* Apicocoronal combined with facial positioning of the implant restoration. Implant-supported restoration is more facial compared to natural dentition. This class of disharmony is more common in female patients and in the anterior sextant (Fig. 26.17).
- *Class III:* Buccal/lingual discrepancy of the implant restoration and the natural teeth. The implant-supported

Fig. 26.16 Class I: Apicocoronal discrepancy between the implant-supported restoration natural dentition. Implant-supported restorations are more apical to natural dentition. This is more common in the anterior sextant.



Fig. 26.17 Class II: Apicocoronal and faciolingual discrepancy between the implant-supported restoration natural dentition. Implant-supported restorations are more facial to natural dentition. This is more common in the anterior sextant.



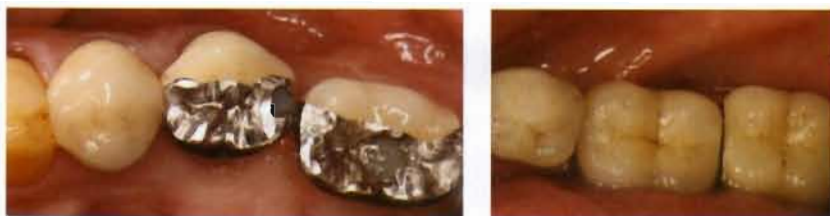


Fig. 26.18 Class III: Buccal–lingual discrepancy between the implant-supported restoration natural dentition. Implants are lingual to natural dentition. This is more common in the posterior sextant.



Fig. 26.19 Class IV: Opening of the proximal contact mesial to the implant-supported restoration due to mesial migration of teeth. This is more common in the posterior sextant.



Fig. 26.20 Class V: Opening of contacts between implant-supported restoration. This has only been observed in the posterior maxilla.

restoration is more lingual compared to the natural dentition. This is observed mostly in the posterior mandible. There is no gender bias for this class (Fig. 26.18).

- **Class IV:** Opening of the proximal contact mesial to the implant-supported restoration. This is the most common discrepancy observed where teeth and

implant restorations coexist. There is no arch or gender bias for this class (Fig. 26.19).

- **Class V:** Opening of the proximal contact between two implant-supported restorations. This is more common in the posterior maxilla. This is the least common class of discrepancy (Fig. 26.20).

Table 26.1 A risk assessment score to help in identifying the at-risk patient

Score	0	1	2
Position	Teeth distal to the implant	Teeth mesial to the implant	
Facial Form	Round	Brachycephalic	Long
Age	65–85	40–65	20–40
Number of implants	Fully edentulous	Partially edentulous	Single tooth (particularly anterior)
Functional importance	Tooth guided	Combination of tooth and implant guided	Implant guided
Esthetic demand	Not demanding	Average	Highly demanding
Smile line	Low	Average	High or gummy smile
Alveolar housing	Thick	Average	Thin
Tissue	Thick	Average	Thin
Time of placement	Delayed with prior grafting with nonresorbable material	Delayed	Immediate

Patient will be assigned a score based on the criteria described in the table. The higher the score, the more at-risk the patient.

Take-home hints

- Risk assessment guidelines should be considered at the time of treatment planning (Table 26.1).
- Esthetics will get worse with time.
- Alternative surgical protocols should be utilized when possible.
- Checking and rechecking occlusion is mandatory at recall.
- Checking and correction of proximal contacts at recall visit.
- Biomechanical disadvantages can become a problem in the long term.
- Less than ideal tooth-implant distance can cause marginal bone loss on teeth adjacent to the implants due to growth.
- Patient's informed consent regarding to craniofacial growth is mandatory.

References

1. Daftary F, Mahallati R, Bahat O, Sullivan RM. Lifelong craniofacial growth and the implications for osseointegrated implants. *Int J Oral Maxillofac Implants* 2013; **28**(1): 163–9.
2. Andersson B, Bergenblock S, Fürst B, Jemt T. Long-term function of single-implant restorations: a 17- to 19-year follow-up study on implant infraposition related to the shape of the face and patients' satisfaction. *Clin Implant Dent Relat Res* 2013; **15**(4): 471–80.
3. Bernard JP, Schatz JP, Christou P, Belser U, Kiliaridis S. Long-term vertical changes of the anterior maxillary teeth adjacent to single implants in young and mature adults. A retrospective study. *J Clin Periodontol* 2004; **31**(11): 1024–8.
4. Carmichael RP, Sandor GK. Dental implants, growth of the jaws, and determination of skeletal maturity. *Atlas Oral Maxillofac Surg Clin North Am* 2008; **16**(1): 1–9.
5. Cronin RJ, Jr, Oesterle LJ. Implant use in growing patients. Treatment planning concerns. *Dent Clin North Am* 1998; **42**(1): 1–34.
6. Cronin RJ, Jr, Oesterle LJ, Ranly DM. Mandibular implants and the growing patient. *Int J Oral Maxillofac Implants* 1994; **9**(1): 55–62.
7. Heij DG, Opdebeeck H, van Steenberghe D, Kokich VG, Belser U, Quirynen M. Facial development, continuous tooth eruption, and mesial drift as compromising factors for implant placement. *Int J Oral Maxillofac Implants* 2006; **21**(6): 867–78.
8. Jemt T. Measurements of tooth movements in relation to single-implant restorations during 16 years: a case report. *Clin Implant Dent Relat Res* 2005; **7**(4): 200–8.
9. Jemt T, Ahlberg G, Henriksson K, Bondevik O. Changes of anterior clinical crown height in patients provided with single-implant restorations after more than 15 years of follow-up. *Int J Prosthodont* 2006; **19**(5): 455–61.
10. Jemt T, Ahlberg G, Henriksson K, Bondevik O. Tooth movements adjacent to single-implant restorations after more than 15 years of follow-up. *Int J Prosthodont* 2007; **20**(6): 626–32.
11. Jemt T, Lekholm U. Measurements of buccal tissue volumes at single-implant restorations after local bone grafting in maxillas: a 3-year clinical prospective study case series. *Clin Implant Dent Relat Res* 2003; **5**(2): 63–70.
12. Oesterle LJ, Cronin RJ, Jr. Adult growth, aging, and the single-tooth implant. *Int J Oral Maxillofac Implants* 2000; **15**(2): 252–60.
13. Oesterle LJ, Cronin RJ, Jr., Ranly DM. Maxillary implants and the growing patient. *Int J Oral Maxillofac Implants* 1993; **8**(4): 377–87.
14. Op Heij DG, Opdebeeck H, van Steenberghe D, Quirynen M. Age as compromising factor for implant insertion. *Periodontol* 2000 2003; **33**: 172–84.
15. Schwartz-Arad D, Bichacho N. Effect of age on single implant submersion rate in the central maxillary incisor region: a long-term retrospective study. *Clin Implant Dent Relat Res* 2015; **17**(3): 509–14.
16. Ainamo A, Ainamo J, Poikkeus R. Continuous widening of the band of attached gingiva from 23 to 65 years of age. *J Periodontol Res* 1981; **16**(6): 595–9.
17. Ainamo J, Talari A. The increase with age of the width of attached gingiva. *J Periodontol Res* 1976; **11**(4): 182–8.
18. Akgul AA, Toygar TU. Natural craniofacial changes in the third decade of life: a longitudinal study. *Am J Orthod Dentofacial Orthop* 2002; **122**(5): 512–22.
19. Bishara SE, Jakobsen JR, Hession TJ, Treder JE. Soft tissue profile changes from 5 to 45 years of age. *Am J Orthod Dentofacial Orthop* 1998; **114**(6): 698–706.
20. Bishara SE, Jakobsen JR, Treder J, Nowak A. Arch width changes from 6 weeks to 45 years of age. *Am J Orthod Dentofacial Orthop* 1997; **111**(4): 401–9.
21. Bishara SE, Jakobsen JR, Treder J, Nowak A. Arch length changes from 6 weeks to 45 years. *Angle Orthod* 1998; **68**(1): 69–74.
22. Bishara SE, Jakobsen JR, Treder JE, Stasi MJ. Changes in the maxillary and mandibular tooth size-arch length relationship from early adolescence to early adulthood. A longitudinal study. *Am J Orthod Dentofacial Orthop* 1989; **95**(1): 46–59.
23. Bishara SE, Treder JE, Damon P, Olsen M. Changes in the dental arches and dentition between 25 and 45 years of age. *Angle Orthod* 1996; **66**(6): 417–22.
24. Bishara SE, Treder JE, Jakobsen JR. Facial and dental changes in adulthood. *Am J Orthod Dentofacial Orthop* 1994; **106**(2): 175–86.
25. Bondevik O. Changes in occlusion between 23 and 34 years. *Angle Orthod* 1998; **68**(1): 75–80.
26. Enlow DH. Facial growth and development. *Int J Oral Myol* 1979; **5**(4): 7–10.
27. Forsberg CM, Eliasson S, Westergren H. Face height and tooth eruption in adults – a 20-year follow-up investigation. *Eur J Orthod* 1991; **13**(4): 249–54.
28. Iseri H, Solow B. Continued eruption of maxillary incisors and first molars in girls from 9 to 25 years, studied by the implant method. *Eur J Orthod* 1996; **18**(3): 245–56.
29. Sarnas KV, Solow B. Early adult changes in the skeletal and soft-tissue profile. *Eur J Orthod* 1980; **2**(1): 1–12.
30. Tallgren A, Solow B. Age differences in adult dentoalveolar heights. *Eur J Orthod* 1991; **13**(2): 149–56.
31. Thilander B, Odman J, Gröndahl K, Friberg B. Osseointegrated implants in adolescents. An alternative in replacing missing teeth? *Eur J Orthod* 1994; **16**(2): 84–95.

32. Thilander B, Odman J, Jemt T. Single implants in the upper incisor region and their relationship to the adjacent teeth. An 8-year follow-up study. *Clin Oral Implants Res* 1999; 10(5): 346–55.
33. Thilander B, Odman J, Lekholm U. Orthodontic aspects of the use of oral implants in adolescents: a 10-year follow-up study. *Eur J Orthod* 2001; 23(6): 715–31.
34. West KS, McNamara JA, Jr. Changes in the craniofacial complex from adolescence to midadulthood: a cephalometric study. *Am J Orthod Dentofacial Orthop* 1999; 115(5): 521–32.
35. Koori H, Morimoto K, Tsukiyama Y, Koyano K. Statistical analysis of the diachronic loss of interproximal contact between fixed implant prostheses and adjacent teeth. *Int J Prosthodont* 2010; 23(6): 535–40.
36. Tarlow JL. The effect of adult growth on an anterior maxillary single-tooth implant: a clinical report. *J Prosthet Dent* 2004; 92(3): 213–15.
37. Jemt T, Lekholm U. Single implants and buccal bone grafts in the anterior maxilla: measurements of buccal crestal contours in a 6-year prospective clinical study. *Clin Implant Dent Relat Res* 2005; 7(3): 127–35.
38. Rossi E, Andreasen JO. Maxillary bone growth and implant positioning in a young patient: a case report. *Int J Periodontics Restorative Dent* 2003; 23(2): 113–19.
39. Odman J, Gröndahl 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* 1991; 13(4): 279–86.
40. Thilander B, Odman J, Gröndahl K, Lekholm U. Aspects on osseointegrated implants inserted in growing jaws. A biometric and radiographic study in the young pig. *Eur J Orthod* 1992; 14(2): 99–109.
41. Sennerby L, Odman J, Lekholm U, Thilander B. Tissue reactions towards titanium implants inserted in growing jaws. A histological study in the pig. *Clin Oral Implants Res* 1993; 4(2): 65–75.
42. Albert AM, Ricanek K Jr., Patterson E. A review of the literature on the aging adult skull and face: implications for forensic science research and applications. *Forensic Sci Int* 2007; 172(1): 1–9.
43. Carrion JB, Barbosa IR. Single implant-supported restorations in the anterior maxilla. *Int J Periodontics Restorative Dent* 2005; 25(2): 149–55.
44. Forsberg CM, Odenrick L. Changes in the relationship between the lips and the aesthetic line from eight years of age to adulthood. *Eur J Orthod* 1979; 1(4): 265–70.
45. Bjork A, Skieller V. Growth of the maxilla in three dimensions as revealed radiographically by the implant method. *Br J Orthod* 1977; 4(2): 53–64.
46. Thilander B. Basic mechanisms in craniofacial growth. *Acta Odontol Scand* 1995; 53(3): 144–51.
47. Bahat O, Handelsman M. Use of wide implants and double implants in the posterior jaw: a clinical report. *Int J Oral Maxillofac Implants* 1996; 11(3): 379–86.
48. Balshi TJ, Hernandez RE, Pryszlak MC, Rangert B. A comparative study of one implant versus two replacing a single molar. *Int J Oral Maxillofac Implants* 1996; 11(3): 372–8.
49. Balshi TJ, Wolfinger GJ. Two-implant-supported single molar replacement: interdental space requirements and comparison to alternative options. *Int J Periodontics Restorative Dent* 1997; 17(5): 426–35.
50. Geramy A, Morgano SM. Finite element analysis of three designs of an implant-supported molar crown. *J Prosthet Dent* 2004; 92(5): 434–40.
51. Seong WJ, Koriath TW, Hodges JS. Experimentally induced abutment strains in three types of single-molar implant restorations. *J Prosthet Dent* 2000; 84(3): 318–26.
52. Belser U, Buser D, Higginbottom F. Consensus statements and recommended clinical procedures regarding esthetics in implant dentistry. *Int J Oral Maxillofac Implants* 2004; 19 (Suppl): 73–4.
53. Ribeiro-Junior PD, Padovan LE, Gonçalves ES, Nary-Filho H. Bone grafting and insertion of dental implants followed by Le Fort advancement for correction of severely atrophic maxilla in young patients. *Int J Oral Maxillofac Surg* 2009; 38(10): 1101–6.
54. Watzek G, Zechner W, Crismani A, Zauza K. A distraction abutment system for 3-dimensional distraction osteogenesis of the alveolar process: technical note. *Int J Oral Maxillofac Implants* 2000; 15(5): 731–7.
55. Rompen E, Raepsaet N, Domken O, Touati B, Van Dooren E. Soft tissue stability at the facial aspect of gingivally converging abutments in the esthetic zone: a pilot clinical study. *J Prosthet Dent* 2007; 97(6 Suppl): S119–25.
56. Forsberg CM. Facial morphology and ageing: a longitudinal cephalometric investigation of young adults. *Eur J Orthod* 1979; 1(1): 15–23.
57. Opdebeeck H, Bell WH. The short face syndrome. *Am J Orthod* 1978; 73(5): 499–511.
58. Opdebeeck H, Bell WH, Eisenfeld J, Mishelevich D. Comparative study between the SFS and LFS rotation as a possible morphogenic mechanism. *Am J Orthod* 1978; 74(5): 509–21.
59. Chee WW, Torbati A, Albouy JP. Retrievable cemented implant restorations. *J Prosthodont* 1998; 7(2): 120–5.
60. Kern M, Sasse M. Ten-year survival of anterior all-ceramic resin-bonded fixed dental prostheses. *J Adhes Dent* 2011; 13(5): 407–10.