original article

What is the appropriate age for dental implant placement?

Abstract / Introduction: *The absence of a tooth may cause functional, esthetic and emotional problems to a patient. For more than three decades, osseointegrated implants have been used as an alternative method to replace missing teeth, as they have shown good long-term results. Single tooth implants are placed in many young patients, but slight changes in position of the gingival margin may compromise the esthetic outcomes of such rehabilitations. Implants retard vertical dentoalveolar development, for this reason, they are compared to ankylosed teeth by many authors, as they do not erupt together with adjacent teeth. In the case of patients that could still grow up, that means the implant-supported prostheses may result in infra-occlusion.* Objective: *Since a variety of authors report post-adolescent growth, this literature review aimed to indicate the most adequate moment for osseointegrated implant placement, taking into account residual craniofacial growth.*
Keywords: *Endosseous dental implant. Maxillofacial development. Age determination by skeleton.*

Bruna Moog ELY
Specialist in Orthodontics, ABO/RS.

Carlos Alberto Estevanell TAVARES
Professor, Postgraduate program, ABO-RS.

doi: http://dx.doi.org/10.14436/2237-650X.8.2.091-099.oar

How to cite this article: Ely BM, Tavares CAE. What is the appropriate age for dental implant placement? Dental Press Implantol. 2014 Apr-June;8(2):91-9.

Submitted: August 07, 2014 - **Revised and accepted:** June 02, 2014

Contact address: Bruna Moog Ely
Rua Osvaldo Aranha, 759 - Centro - São Leopoldo/RS — Brazil
E-Mail: brunaely@gmail.com

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

INTRODUCTION

When a young patient has a missing tooth in the anterior region, there are many treatment possibilities: Orthodontic space closure, self-transplant and prosthetic reposition. Osseointegrated implants functioning as prosthesis support are among the prosthetic options.

Implants have been used as an alternative method for missing teeth for more than 30 years because they show good performance in the long run. Nowadays, single implants — when wisely indicated — can be placed in young patients and remain in function for many years. However, slight changes in gingival margin position of single implants can hinder the esthetic outcomes of these rehabilitation procedures.[1]

Some authors compare implants with ankylosed teeth[2-5] as they do not erupt together with adjacent teeth and can retard vertical dentoalveolar development at these sites. Therefore, implant-supported prostheses may result in infra-occlusion in growing patients.[6]

A certain amount of residual craniofacial growth — after the pubertal growth peak — has been reported in humans.[7-10] Such changes, even the small ones, can affect treatment outcomes when osseointegrated implants are used.[2]

Since these facts are seen as greatly significant to determine the appropriate moment for implant placement, this paper aimed to discuss the most adequate skeletal age for patients to undergo implant placement.

LITERATURE REVIEW

Tooth absence is usually caused by trauma, congenital absence or dental diseases. As decay levels are decreasing among young people nowadays, agenesis and dental trauma are the major cause for tooth absence in the anterosuperior region. Except for third molars, the most often absent teeth are second lower premolars followed by upper lateral incisors with an incidence of 1.67%.[11] In all dental trauma investigations conducted by Bastone et al,[12] the upper lateral incisor was the most frequently injured tooth.

Correcting anterior tooth absence is of major esthetic, functional and psychological importance for the patient. To this end, there are many options, including orthodontic space closure which is preferred for providing esthetic satisfaction. Nevertheless, some cases do not yield satisfactory outcomes due to dental anatomy, adjacent teeth color and medial line asymmetry. When there is appropriate intercuspidation, space closure is contraindicated and prosthetic reposition becomes the treatment of choice. Fixed denture is not recommended for young people due to providing risk of pulp injury to neighboring teeth. In these cases, removable denture or adhesive prostheses are the alternatives; however, they might yield unesthetic results.[4] Tooth implant followed by implant-supported prosthesis placement has become an extremely actual alternative.[13]

According to Branemark,[14] dental implant placement where there is one tooth

only, imposes some requirements to be fulfilled before surgery:

» Adequate general and oral health;
» Minimal of 5-mm edentulous mesiodistal space;
» Minimal of 5-mm interarch vertical distance to make prosthetic reposition possible;
» Good gingival relation of the edentulous area with the neighboring tooth;
» A 4-mm wide, 7-mm high, 5.5-mm deep osseous volume;
» Absence of facial growth.

Facial residual growth

Craniofacial growth slows down after puberty, which occurs earlier in women than men. Research findings undisputably confirm the presence of continual craniofacial morphological changes, that is to say, facial residual growth occurs after puberty.[15]

One of the theories of facial height increase derives from continual tooth eruption occurring even after occlusion has been established in post-adolescence. After complete eruption, the teeth show continuous eruption which goes along with the increase of the alveolar process height until facial growth ends, and probably at a very small scale along a subsequent period.[16]

Forsberg et al[17] superimposed 30 cephalograms with a 20-year gap among them. All linear measures, except for overjet and overbite, showed significant increase from 25 to 45 years of age. Total facial height increased 1.6mm, mainly in the lower face (five times more than the upper face). Upper and lower dentoalveolar height increased in both arches. Upper incisors tend to upright with age, in which case eruptive movement also tends to occur. Dental vertical move is not limited by the teeth only, but it also involves the lining tissues, including the alveolar bone, which indicates vertical eruptive movement and development of adjacent tissues. Tallgren and Sollow[18] confirm that a continuous increase of the lower face accompanies an increase of the dentoalveolar anterior height in both arches.

Articles that relate maxillary and mandibular growth with the development of teeth with implants confirm that the later does not follow compensatory mechanism during growth. That is why maxillary vertical growth dramatically affects implant position, since it exceeds any other dimensional growth. As a compensation, the teeth continue to erupt so as to maintain interocclusal distance.[19,20]

Thilander et al[4] investigated 15 adolescents in need of single implants. They were all the same dental age (totally erupted permanent teeth), but at different chronological age (15 years and 4 months, on average). In four patients with implant-supported denture placed in the anterior region, the position of the fixed crown was vertically changed to a clinically and esthetically unacceptable position after a three-year follow-up. Not only a difference between incisal margins was found, but

also an apical displacement at the gingival margin of the implant-supported crown. The position of infra-occlusion in the incisors region was also checked by the model measures and radiographs, with a variation of 0 to 1.6 mm over three years. The greatest increase in body height during the follow-up period was seen in the patient with most noticeable infra-occlusion. There was great individual variation in changes of the incisors region. Neither the dental stage accounts for the infra-occlusion degree, since all patients were at the same stage, nor the chronological age itself can be used as a guide for implant placements in adolescents. Therefore, it is important to check patient's skeletal maturation age before implant placement.

Bishara et al[21] found that changes occurring from 25 to 45 years old are small, although statistically significant. Their findings point out that both in men and women there occur anteroposterior and vertical skeletal changes within this time interval. This was also confirmed by Bondevik[6] who examined the natural growth occurring from 22 to 33 years old in Norwich adults. The study material comprised two cephalograms from each patient, with an interval of 11 years in between. The statistically significant changes found for both males and females were: increased facial height, mainly in the lower face; and increased mandibular length. Women also had significant posterior mandibular rotation. Lower and upper incisors were retroclined in both men and women. These study findings support the opinion that facial growth continues until, at least, the third and fourth life decades, even though the changes are small when compared to those occurring up to the second life decade.

It is worth noticing that when an implant osseointegrates in a growing socket, alveolar development ceases in that area, although growth in adjacent regions continues in the three dimensions. Since implant-supported crowns do not follow the continual eruption of neighboring teeth, it is particularly important to determine the amount of eruption in adolescents and young adults so that implant-supported prostheses in growing individuals are not at risk of infra-occlusion (Fig 1). Iseri and Solow[5] concluded that eruption speed peak happens at 18 years old and is followed by a decrease. From 9 to 25 years old there was an average eruption of 6 mm downward and 2.5 mm forward of the upper central incisor. Variation in eruption amount and direction was great due to two main factors: Individual maturity and individual facial growth pattern.

Using the same sample of 1994, Thilander et al.[22,23] conducted other studies in 1999 and 2001 with an 8 and 10-year follow-up with the aim of finding out whether implant-supported crowns in the anterosuperior region were at risk for infra-occlusion. Even when between the fourth and eighth follow-up year there was no increase in adolescents' body height, the vertical incisal mean of the implant crown had gone from 0.46 mm to 0.95 mm. Over the 10-year follow-up, there was gradual increase of

Figure 1. A) Female patient with left upper central incisor absent at the age of 19 years and 4 months old before orthodontic treatment. **B**) Patient when she was 20 years and 8 months old after orthodontic treatment and placement of an implant-supported prosthesis in the 21st region. **C**) Patient when she was 27 years and 5 months old showing unevenness of the gingival margin and infra-occlusion of the implant-supported crown. Source: Case lent by Dr. Carlos Alberto Tavares.

Figure 2. A) Male patient at the age of 15 years and 5 months old with implant-supported crown in the upper lateral incisor. **B**) After a 3-year follow-up with a 1.6 mm infra-occlusion. **C**) When he was 25 years and 2 months old, a 2.2 mm-infra-occlusion degree was noticed.

infra-occlusion (0.1 mm per year). (Fig 2).

Heij et al[24] conducted a literature review to remind us that patients with extreme facial types (long or short) must be given special attention because they show maxillary differential development even when they reach the adult stage. Short-faced patients showed more horizontal teeth movement, whereas long-faced patients showed more vertical movement. Clinically, these movements would result in more palatinized implants in short-faced patients, and more infra-occluded implants in long-faced patients.

Bondevik[25] assessed dentofacial changes in patients' third and fourth life decades, and confirmed continuous facial growth in adults. The author analyzed 93 cephalograms taken at 22.6, 33, and 43 years old (on average), and their results showed growth of anterior and posterior face.

Importantly, fixed chronological age cannot guide implant placement. Additionally, dental age pointing to total teeth eruption and complete or nearly complete skeletal maturation is not enough to avoid implant-supported crown infra-occlusion, given that slight continual eruption of adjacent teeth can occur during post-adolescence.

Methods to assess growth ending

In a conference on implants held in 1995,[26] it was established that postponing implant placement was preferred until craniofacial growth process ended, specially in cases of partial edentulism. It is worth noting that the age of growth ending varies considerably. Growth peak is expected to occur at the age of 12 for girls, and at the age of 14 for boys, although there can be a 6-year variation As for implants, the troublesome age for girls is 15, and for boys it is 17 years old. In addition to the observed variability among facial types, longer periods can be considered (changes can happen even when individuals are 25 years old). Certainly, chronological age is not enough to estimate growth ending. A true growth assessment should be developed through the following procedures:

» Superimposition of cephalometric tracings taken every 6 months until there is no growth change over 1 year. However, necessary radiation and delaying are disadvantages;

» Yearly assessment of body growth over 2 years to be sure growth is less than 0.5 cm/year. However, it is also considered a time-consuming method;

» Observation of changes in dental arch position. For instance, second molar eruption;

» Assessment of skeletal age based on hand and wrist radiograph to check whether there was capping of epiphysis over diaphysis, including the radius.

Superimposition of cephalometric tracings

According to Kokich,[27] the best way to assess facial growth is by means of sequential cephalometric superimposition. The author recommends to wait until the end of body growth to take a cephalometric

radiograph, repeating the procedure after 6 months to 1 year. When these radiographs are superimposed and there are no changes in vertical facial height (nasion to menton), it indicates most of facial growth is finished. If an implant is placed at this moment, there is no expectation of adjacent teeth eruption.

In his article, Kokich[27] mentioned Fudalej's[28] Masters thesis conducted to determine when adolescent growth ends. The sample comprised 150 boys and 150 girls who had finished orthodontic treatment and had lateral radiographs taken when treatment ended and 10 years after that. Statistical analyses revealed that the average age for growth ending is 17 years for girls and 21 years for boys. Since we are dealing with means, such information is not suitable for a specific patient. The surgeon must superimpose cephalometric radiographs at intervals of 1 year at least to check if facial growth is complete.

Hand and wrist radiographs are also indicated to monitor patient growth. When there is capping of epiphysis over diaphysis, including the radius, analysis should be supplemented by superimposing cephalometric tracings taken with a minimal 6-month interval in between. When there is no alteration from one radiograph to the next, the patient will be ready for implant placement.[29]

Body growth

Hunter[30] conducted a study to assess the relationship between facial and body growth during adolescence. The author used semestral data of chronological and skeletal age as well as stature of 59 patients for seven years. He was able to reach some conclusions: Facial growth peak coincided with the height growth peak for the majority of patients; facial growth continues over the third decade of life in men even after body growth ends; female growth finishes by the end of the second decade of life, and it possibly ends along with stature growth.

Dental age

Bambha and Van Natta[31] carried out a research comprising hand and wrist radiographs with a six-month interval in between and plaster models of 60 patients to assess the relationship among skeletal maturation, occlusion and tooth eruption. The authors concluded that there is no evidence of a potential relationship between tooth eruption and skeletal maturation.

Hand and wrist radiographs

The study by Verma et al[32] aimed to investigate how valid radiograph analyses are to estimate the amount of residual growth of the face. Cephalograms of 49 patients' hands and wrists were analyzed at an average interval of 3 years. Stature, cranial base length, maxillary length and mandibular measures were assessed and statistically compared. Results showed a strong correlation between stature growth and prediction based on hand and wrist radiographs. As to craniofacial structures, there was no significant correlation between the increase in cranial base growth and total mandibular length with growth prediction

made possible with the help of hand and wrist radiographs. That is, hand and wrist radiographs do not provide precise information about residual growth, given that patients show different growth patterns and the different craniofacial structures show an individual potential.

FINAL CONSIDERATIONS

» Osseointegrated implants might behave as ankylosed teeth in growing patients, since they do not erupt as adjacent teeth and do not allow alveolar development in the area;

» Facial growth does not end after puberty spurt. Facial height and teeth eruption continue to increase during adulthood;

» The most reliable method to assess the end of facial growth is cephalometric superimposition with a minimal 6-month interval in between, since it provides an individualized analysis for each patient;

» The appropriate age for osseointegrated dental implant placement is very unique, since the end of facial growth is widely variable and has to be determined by means of cephalometric radiograph superimposition for each patient.

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