JOURNAL of
OSSEOINTEGRATION

JUDITH OTTONI[1], MÁRCIA GABRIELLA[2]

Federal University of Espírito Santo (UFES), Brazil
[1] MSc in Physiology Science, Specialist in Periodontics, Pontifical Catholic University of Rio de Janeiro, Brazil (PUC-RJ) - Private Practice
[2] Specialis in Dental Radiology, Specialist in Facial Orthopedics and Orthodontics, Msc. In Public Health, PhD student in Dental Clinic / Radiology and Dental Imaging

Dental implants three-dimensional position affected by late facial bone growth: follow-up of 12 to 15 years

ABSTRACT

Background The three-dimensional (3D) position of the osseointegrated dental implants provides favorable esthetical results and preserves the surrounding soft and hard tissues architecture in a long term analysis. However, recent studies demonstrate that the continued growth at adult life can also be noticed on the craniofacial skeleton. Therefore, considerable change may occur interfering on the relationship between a fix structure, the implant, and the adjacent teeth, with the possibility of forward and downward movement, due to the craniofacial growth. The question is: how long the harmonic relationship, previously established between the crown supported implant and natural teeth, is going to maintain esthetically pleasant? This article is based on three cases of adult patients with ages varying from 38 to 60 years old, when implants were inserted, and afterwards these patients were followed up during 12 to 15 years. It has been concluded that the continued craniofacial growth can lead to an infraocclusion of the implants–supported crown and to diasthem, which may negatively impact on both the aesthetics and the chewing quality.

KEY WORDS Aesthetics; Craniofacial growth; Osseointegrated implants; Three-dimensional position.

INTRODUCTION

In the last two decades, the dental aesthetics has been considered the main goal in implant rehabilitations due to demand of increasingly younger patients to require replacement of missing or unerupted teeth in maxillary and mandible anterior regions. The great incidence of missing teeth, due to congenital absence, has its higher frequency in premolars and lateral incisors (1). Successful oral implants rehabilitations depend on the integration and harmony between the soft and hard tissues components and their relationship between implant-supported crowns and remaining teeth.

The placement of dental implants requires an accurate planning taking into account the anatomy limitations and the restorative goals.

The adequate 3D position for placing dental implants plays a major role in esthetic excellence of the future prostheses, thus, it is necessary to standardize that procedure, based on clinical and radiographic findings and dentoalveolar morphology. It should be considered the apicocoronal, mesiodistal, and buccopalatal relationships as well as to highlight the importance of the placement of dental implant in an axial position.

Research with human beings focusing on establishing the vertical dimensions in implants had related the interproximal height of bone (IHB) to prediction the papilla height, having as reference the future contact point from restoration to crestal bone. It was noted that the distance from 4 to 5 mm suggests a good prognosis with the papilla almost always present; from 6 to 7 mm indicates a guarded prognosis; and over 7 mm points out a poor prognosis (2).

In Table 1 are summarized the apical-coronal measures suggested by some authors.

The implant marginal bone loss is related to adjacent teeth, which indicates a strong correlation between the horizontal distance and bone loss. By assessing the mesiodistal measurements some authors (7) concluded that, the lower horizontal distance

APICAL-CORONAL PLANE	
Phillips & Kois, 1998 (3)	The implant is placed 3–5 mm apical to free marginal gingiva from adjacent tooth
Saadum, Legall & Touati, 1999 (4)	The implant is placed 3 mm apical from marginal gingiva or 2 mm from ECJ of the adjacent tooth
Hermam et al., 2000 (5)	The abutment-implant interface should be more coronal, thus less amount of bone is lost; for ITI implants, it is suggested placement that interface 1mm apical from ECJ
Kan et al., 2009 (6)	They suggested that the implant should be placed 3 mm from ECJ of the adjacent tooth

Table 1 *Apical-coronal plane suggested measures.*

between implant and adjacent teeth, the higher the bone loss, suggesting that this distance might ranges from 1.5 to 2.00 mm (7).

Some authors (4) have corroborated that to maintain the interproximal papilla the distance of 2 mm at implant cervical level and adjacent teeth is ideal, while other investigators have established at least 3mm of distance between the implants (8).

As regards the buccopalatal aspects, the authors have suggested that dental implants should be placed 2mm towards palatal or lingual from a tangent on the buccal surface of adjacent teeth.

The more favorable axial position for placing dental implants would be at 45° relative to occlusal plane where provides a better facial contour and labial support, being ideal for the future prosthesis. According to one author the appropriate direction of implant improves the natural aesthetics by showing a better facial emergence profile for the restoration (9).

Although a lot of effort has gone into standardizing the three-dimensional parameters that would benefit the aesthetics for a patient, the long-term evaluation of the maintenance of those excellent outcomes is questionable, since the body dimensional changes are not static. Thus, we can ask: until when?

The bone growth mechanism is by apposition and resorption, being the first accomplished through osteoblasts while the latter is through osteoclasts. The bone does not grow evenly in its whole extension by apposition and resorption process. The periosteum and endosteum can appose bone on an external or internal area to be reabsorb in a contiguous one, allowing different skeletal parts either change their spatial shape as they grow or undergone a remodeling. The biological changes occur throughout the body over time (10). The growth hormone exerts a profound effect on the dimensional changes due to its interference in liver, muscle, fat tissue and bones metabolism. It is released throughout the life following a pulsating pattern. The releasing intensity of growth hormone is not constant throughout the life. It is increasingly from birth to first childhood, and during the childhood it remains somewhat stable. On puberty occurs an abrupt increased secretion, provoked by estrogen and testosterone in females and males, respectively. Following the puberty the hormone releasing intensity droops to a stable value. Ultimately, in senile the releasing intensity and the pulsation droop to their lower levels (11).

The potential of growth might be influenced by several others hormones such as paratohormone from a general epigenetic perspective added to intrinsic genetic factors and extrinsic environmental factors, leading to anatomic changes throughout life (12).

The facial skeletal growth is extremely complex due to combinations between bone sliding, displacement and remodeling of each part of it and of its entire set. One should highlight the great influence of independent functional areas set related to breathing, vision, speech, chewing and smelling (13).

The growth trend noted by cephalometric superposition studies suggests a growth:

- In the maxilla the vertical and horizontal growth takes place into backward and upward, but its displacement is forward and downward (Fig. 1a, 1b).
- In the mandible, following its formation, its growth is coordinated by apposition in the condylar area and posterior border of mandibular upward ramus, and its shape by an intensive activity of apposition and resorption. The horizontal displacement and sliding is forward and rotated down (Fig. 1c, 1d).

This growth does not occur in an even manner, and it can be disturbed as was noted by three studies (1, 14, 15) using the same methodology and the same experimental group. In a sample of six pigs of Pigham strain, 12 weeks old, were placed three implants in lower jaw: one was placed in the mesial socket of the second deciduous premolar on one side, a second was placed in the deciduous canine region on the same side, and a third was inserted in the mesial socket of the first deciduous premolar on the opposite side. In the upper jaw, on implant was placed in the region of the maxillary deciduous lateral incisor. Amalgam markers were placed in the buccal cortical layer of the alveolar process adjacent to implants in order to

allow to superposition the lateral cephalograms from the different recordings. In the control animal, no extraction was performed and no fixtures were inserted, amalgam markers were placed in corresponding areas as in the test pigs. After 165 days, the animals were sacrificed. The results showed that the implants do not become displaced in sagittal and transversal dimensions, thus, do not behave like normal teeth, suggesting by analogy that the single implant should not be placed in young patients. Regarding to fixture-to-teeth relationship, it was noted that in the premolars region of lower jaw, the teeth were positioned superior to and buccally angulated in relation to the fixtures. In the upper jaw, the implants were positioned below the adjacent teeth, but centrally in the alveolar process. Tooth germs adjacent to the fixture had a displaced eruption path, buccally and lingually to the fixture.
Similar changes were noted in a clinical investigation in a group of 15 young, with age ranging from 13 to 19 years old, presenting with missing teeth by congenital absence or trauma and were replaced for implants. In the first 3 years of follow-up, none implant was lost or had significant bone loss, however, infraocclusion from 0.6 to 1.6 mm was noted in those patients with residual craniofacial growth. It was associated with growth changes related to an increase in a body height. The author concluded that age is not the major problem, but the skeletal and dental maturation should be considered to prevent infraocclusion of implants in young patients. It was highlighted that the mesiodistal space should be maintained in order to avoid bone resorptions in the teeth adjacent to implants (16). From the 4-year observation, neither further increase in a body height nor any craniofacial changes were found in any of the patients. However, an increase in infraocclusion was observed reaching to 2.2 mm in ten years. The greatest disadvantages are related to the upper incisor region, especially for lateral incisor due to craniofacial changes post adolescence. Periodontal problems may arise, with marginal bone loss around the adjacent teeth and bone loss buccally to the implants. The shorter the distance between the implant and the adjacent teeth, the larger the reduction of marginal bone level. The authors concluded that the implant-supported prosthetic constructions seems to be a good alternative in adolescents with extensive aplasia, provided that craniofacial growth has ceased or is almost complete (17).
One study (18) changed the previously established paradigms about the nature of specific morphologic changes and adjustmens of the craniofacial complexes associated with post-maturation and age. Moreover, it amplified the assumptions that the growth from childhood to adulthood may be arbitrary. The noted changes were consistent and provided evidence that the craniofacial complex remodeling occurs continuously throughout life. The dimensional changes and the direction of sliding and displacement were different when males and females were analyzed. In figure 2 are exemplified those changes. The relevance of that study (18) leads us to reflect the potential implications in the purposes of treatment in several dental specialties.
The cases reported bellow are from a private

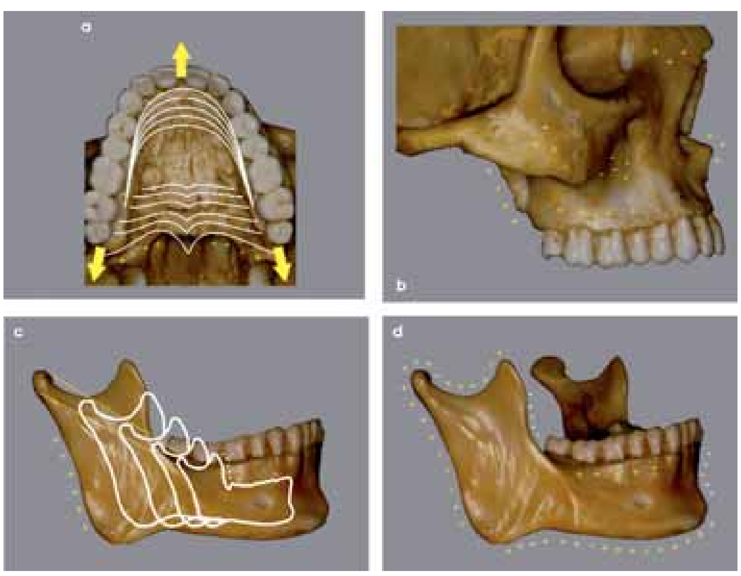


Fig. 1 *Maxillary growth pattern (a and b); mandible growth pattern (c and d).*

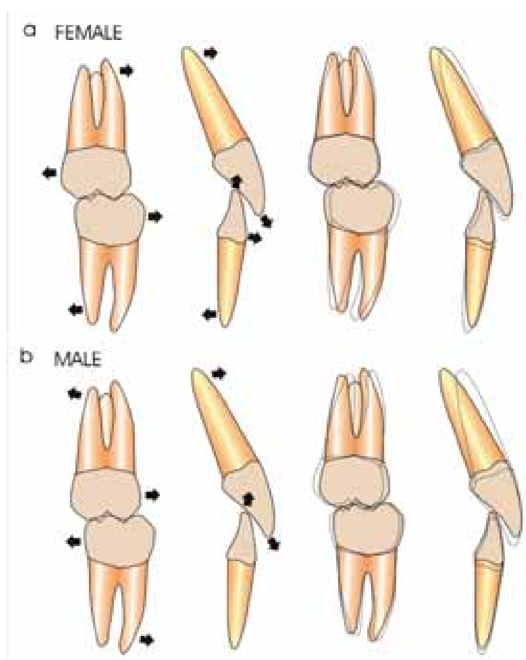


Fig. 2 *Direction of tooth sliding and displacement in females (a) and males (b).*

practice, where usually the photographic and radiographic recordings are not carefully standardized and the difficulties with the maintenance of casts for a long time leads us to rethink the pre-existing concepts of implant dimensional position, which might always be stable, and to open a new horizon of research to be investigated in implantology. In all cases reported below, the initial photographic recording were performed with analog camera and in a certain moment they were again photographed using a digital camera in order to preserve the images.

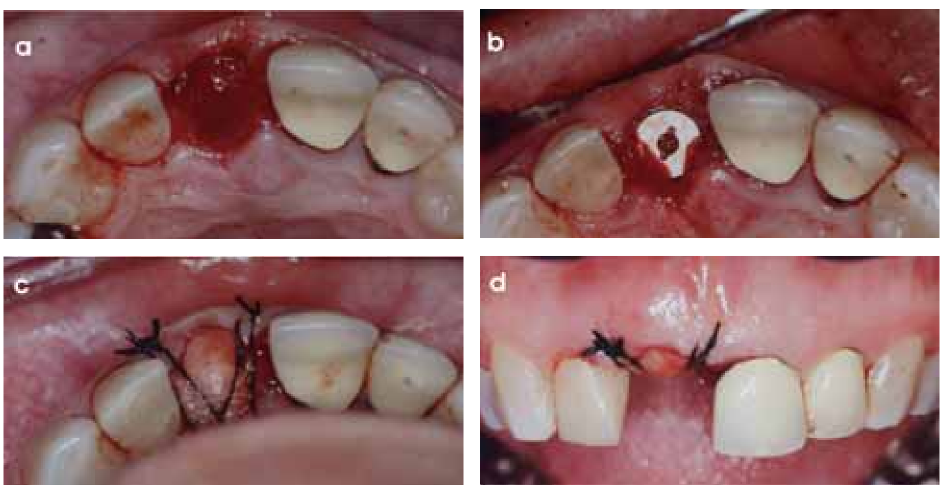
Case 1: follow-up of 12 years

A 46-year old patient with upper right central incisor presented at our office, in 1998, requiring rehabilitation with osseointegrated implant.

Due to the integrity of alveolar bone we chose the immediate placement of a Frialit 2 implant (5.5 x 13 mm). The socket was filled with bone graft (DFDBE) and sealed with connective tissue grafting. In the restorative phase the central (21) and lateral (22) incisor crowns were simultaneously replaced with the screwed-crown on the implant.

In 12-year follow-up was found the intense discrepancy of the gingival and incisal margins between the implant in infraocclusion and the adjacent central incisor.

It was also noted the direction of growth movement forward and downward, where it is clearly observed the root of central incisor adjacent to implant tipped forward. This horizontal and vertical growth vector is according to normal facial growth pattern (Fig. 3-6).



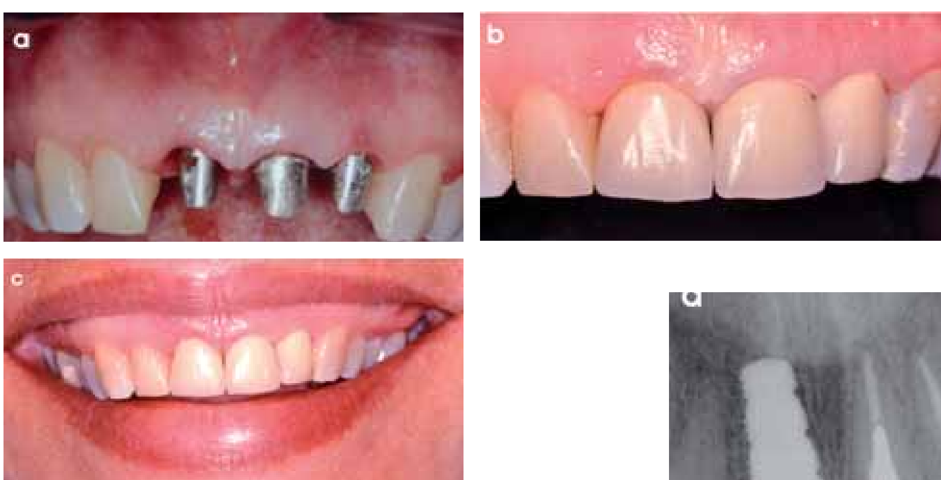


Fig. 3 *Surgical procedures.*
Fig. 4 *The 48-year patient in 1998 with final crowns .*
Fig. 5 *Radiographs taken in 1998 (a) and 2010 (b).*

Fig. 6 *The 12-year follow-up showing displacement forward and downward of the tooth crown adjacent to implant restoration.*

Case 2: follow-up of 12 years

A 58-years patient with missing the lower left molars presented for restorative treatment. The oral rehabilitation was performed with two splinted-crowns on implant. The 12-year follow-up revealed diastema existing between the crowns on implants and the natural teeth. The main complaint of the patient, in that moment was 70 years old, was the food impaction in that area and, due to it, the loss of pleasure of eating (Fig. 7-10).

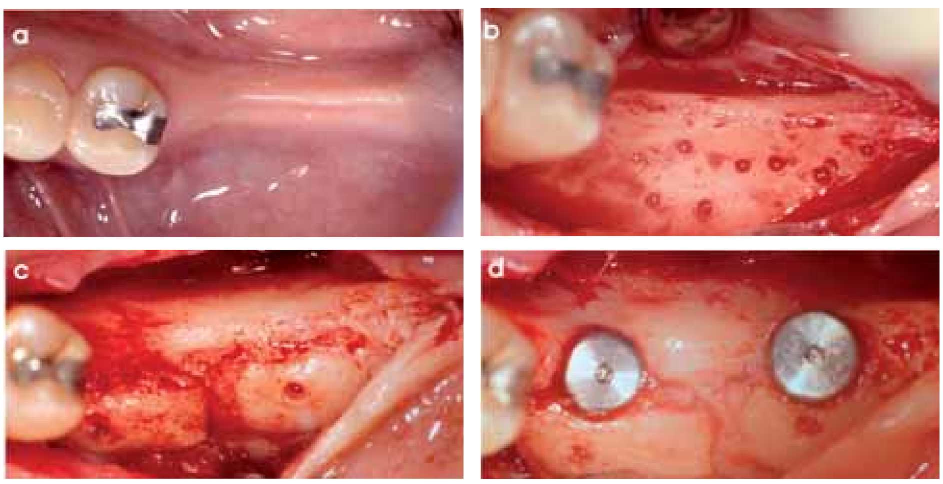


Fig. 7 *Surgical procedures in the 58-year old patient in 1998.*

Fig. 8 *The final crowns in 1998.*

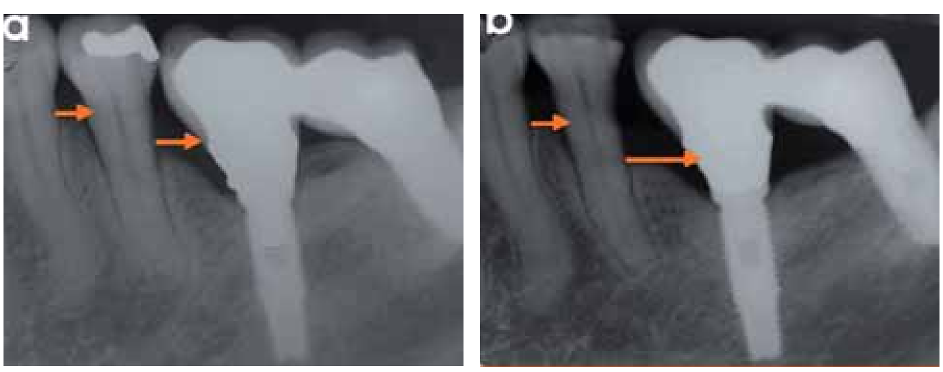


Fig. 9 *Radiographs taken in 1998 (a) and 2010 (b).*

Fig. 10 *The 12-year follow-up showing diastema between the crowns on implants and the natural left second premolar.*

Case 3: follow-up of 15 years

A 31-year old female patient presented with fracture of lower left first premolar (#34) in 1995. Then, the fractured root was removed and immediately a Screw-vent implant (3.75 x 13 mm) was placed. After seven months, the patient was referred to the prosthetist.

The 15-year follow-up showed diastema between the crown on implant and the natural lower left canine (Figs. 11-14)

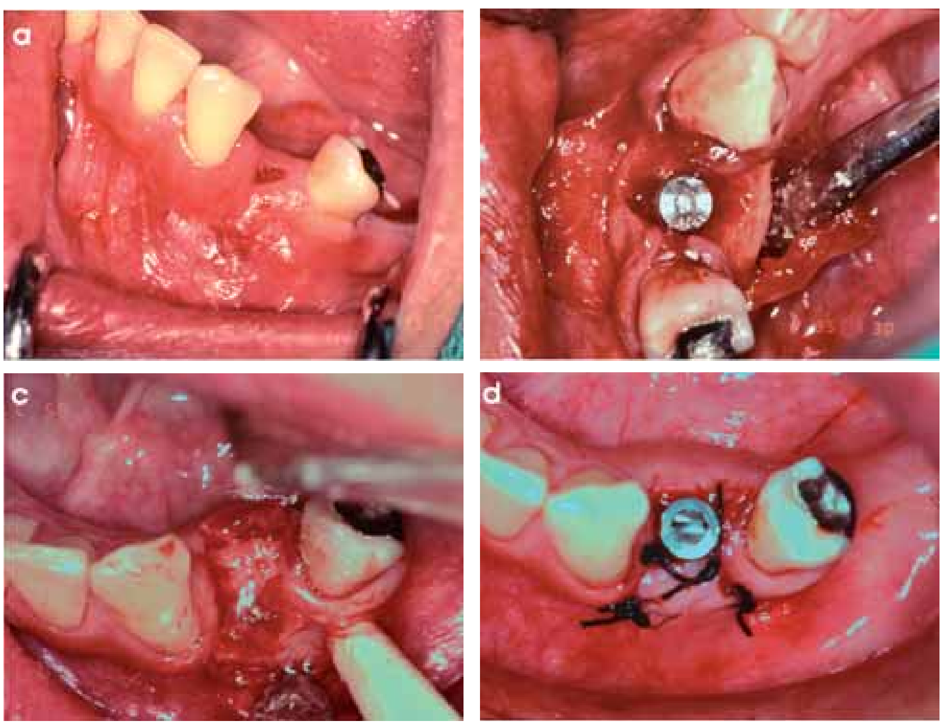


Fig. 11 *Surgical procedures in 1995.*

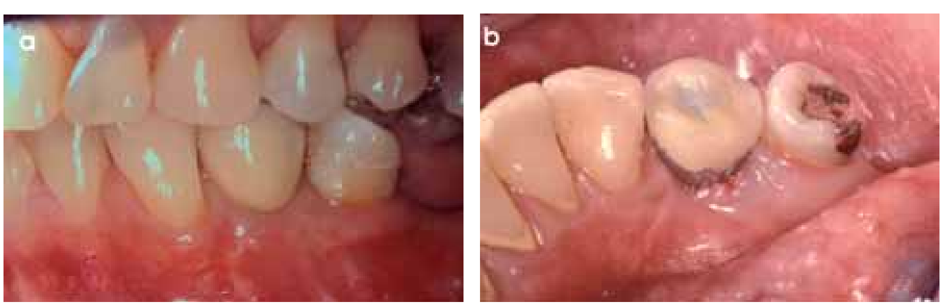


Fig. 12 *The 32-year patient in 1996 with final crown.*

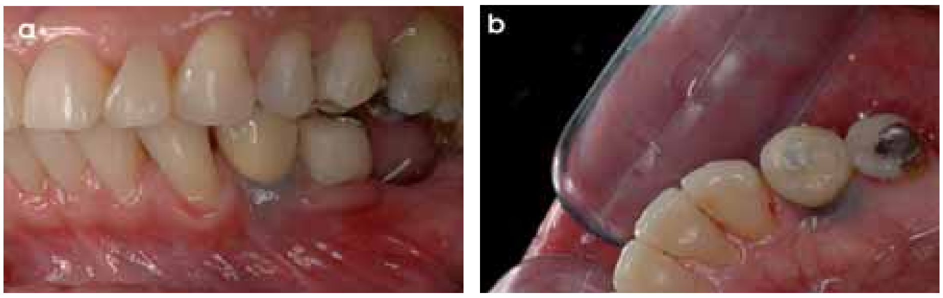


Fig. 13 *The 15-year follow-up showing diastema between the crown on implant and the natural left canine.*

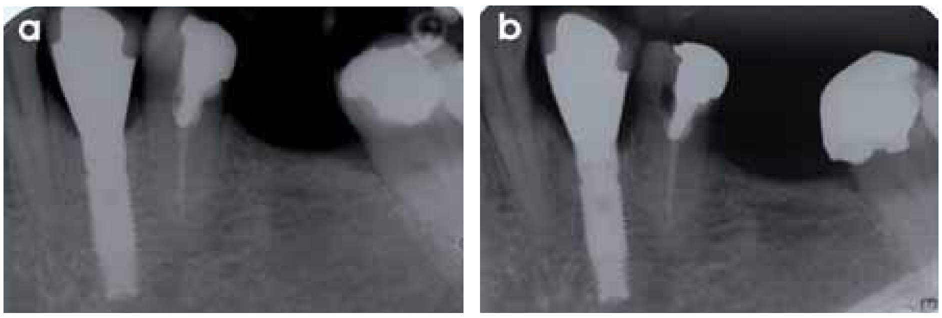


Fig. 14 *Radiographs taken in 1996 (a) and 2010 (b).*

DISCUSSION

The established concept concerning the growth curve suggests that the intense skeletal changes stop after the puberty. The changes would be noted in women up to 18 years old, and in men up to 19 years old (18). Other authors have suggested that the growth is complete at 20 or 23 years old (19, 20).
The indication for rehabilitations on osseointegrated dental implants in adolescents follows that chronology and it is suggested that the confirmation of the cessation of growth to be performed based on wrist radiographs.
When we note the body changes occurring in adulthood, it is expected that those concepts be reviewed and updated, and that this period should not be onsidered as stable morphologically and physiologically.
Some studies have demonstrated a significant increase in dimensions on adulthood, such as the dentoalveolar height growth indicating an eruptive movement of the teeth and a vertical development of the surrounding tissues (21). In 1978, Ainamo already noted those changes, which were related to soft tissue (mucogingival junction, gingiva attachment) and hard structures (nasal base, mandible lower border, and cementoenamel junction). The changes in both bony structures and tooth position interfere significantly with the occlusal relationship that has its growth in micron per year, therefore we should not consider the occlusal arrangement as definitive (22).
Among several and important conclusions drawn by Beherents (10), here are reported a few.

> The craniofacial skeletal growth is continuous in adulthood, and maybe its cessation only occurs with the death, even though an apparent deceleration during this course.
> Both the size and the shape of the craniofacial complex are altered and the growth behavior are differentiated and marked.
> In a young adulthood phase the growth seems be specific between men and women, however in the subsequent phases the vertical dimensions of growth seem common to both genders.
> The growth between men and women is different. The women grow less in every age and more in vertical direction than the men.
> The mandibular plane is rotated forward in men and rotated backward in women. Offset changes in the dentition were noted.

Dramatic changes relative to soft tissues are expected due to great magnitude of skeletal changes, primarily involving elongation of the nose, flatness of the lip, and growth of the chin.

CONCLUSION

The questioning of a potential tooth migration due to occlusal problems were analyzed and discarded in all cases presented herein. Whether the continuous growth noted and reported here is a reality, it leads us to believe that the implants infraocclusion process in relation to adjacent teeth may to become more marked as the patients are younger. It is also important to point out that the biology in adulthood is never static.
Due to lack of standardization of the evidence and the limited number of sample, might not be thinking about the percentage of growth and/or its occurrence.

Currently, it seems prudent to accept that the disorder was caused by facial growth itself. Moreover, we think that the clinicians should give information to patients on changes can occur over the service life of the implant restorations, which may be replaced in the future.
Further research on this subject and its consequences in several fields deserve to be carried out.

REFERENCES

1. *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 Apr;14(2):99-109.*
2. *Salama H, Salama MA, Garber D, Adar P. The interproximal height of bone: a guidepost to predictable aesthetic strategies and soft tissue contours in anterior tooth replacement. Pract Periodontics Aesthet Dent 1998;10(9):1131-41.*
3. *Phillips K, Kois JC. Aesthetic peri-implant site development. Dent Clin North Am 1998;42(1):57-70.*
4. *Saadoun AP, LeGall M, Touati B. Selection and ideal tridimensional implant position for soft tissue aesthetics. Pract Periodontics Aesthet Dent 1999;11(9):1063-74.*
5. *Hermann JS, Buser D, Schenk RK, Cochran DL. Crestal bone changes around titanium implants. A histometric evaluation of unloaded non-submerged and submerged implants in the canine mandible. J Periodontol 2000;71(9):1412-24.*
6. *Kan JY, Rungcharassaeng K, Morimoto T, Lozada J. Facial gingival tissue stability after connective tissue graft with single immediate tooth replacement in the esthetic zone: consecutive case report. J Oral Maxillofac Surg 2009;67(11 Suppl):40-8.*
7. *Esposito M, Ekestubbe A, Gröndahl K. Radiological evaluation of marginal bone loss at tooth surfaces facing single Brånemark implants. Clin Oral Implants Res 1993;4(3):151-7.*
8. *Tarnow DP, Cho SC, Wallace SS. The effect of inter-implant distance on the height of inter-implant bone crest. J Periodontol 2000;71(4):546-9.*
9. *Daftary F. Natural esthetics with implants prostheses. J Esthet Dent 1995;7(1): 9-17.*
10. *Behrents RG. Growth in the aging craniofacial skeleton. In: Cranio-facial growth Series, Monografy #17. Ann Arbor, MI: Center for Human Growth and Development, The University of Michigan; 1985: 1-145.*
11. *Guyton e Hall. Os hormônios hipofisários e seu controle pelo hipotálamo. In: Guyton e Hall tratado de filosofia médica. Philadelfia: 1996;75:847–857.*
12. *Guyton e Hall. Os Hormônios metabólicos da tireóide. In Guyton e Hall tratado de filosofia medica. Philadelfia: 1996;76: 858-869.*
13. *Van Limborgh J. A new view on the control of the morphogenesis of the skull. Acta Morphol. Neerl Scand 1970; 8:143.*
14. *Ödman J, Grondahl K, Lekholm U, Thilander B. The affect of osseointegrated implants on the dento-alveolar development. Eur J Orthod1991;13:279-289.*
15. *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.*
16. *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.*
17. *Thilander B, Odman J, Gröndahl K, Lekholm U.Orthodontic aspects of the use of oral implants in adolescents: a 10-year follow-up study. Eur J Orthod 2001;23:715-731.*
18. *Broadbent BH, Broadbent BH Jr, Golden WH. Bolton standards of dentofacial developemental growth. St Louis: Mosby; 1975.*
19. *Graber TM. Orthodontics. Principles and practice. Philadelphia: W.B. Sauders Co; 1969.*
20. *Björk A, Helm S. Prediction of the age of maximum pubertal growth in body weight. Angle Orthod 1967:37:134-46.*
21. *Björk A, Skieller V. Normal and abnormal growth of the mandible. A synthesis of longitudinal cephalometric implant studies over a period of 25 years. Eur J Orthod1983;5:1-46.*
22. *Ainamo A. Influence of age on the location of the maxillary mucogigival junction. J Periodontal Res1978;13:189-93.*