Review Article

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Implants in Growing Children: Still A Dilemma?

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ABSTRACT

Background: The absence of permanent teeth as a result of dental trauma or congenital aplasia can be seen in children and adolescents which can lead to aesthetic limitations that impair social acceptability and functional difficulties related to speech and mastication. Prosthodontic approach to oral rehabilitation is therefore required for such growing patients. Treatment plan to replace missing teeth is based on each patient's systemic condition, developmental phase, number of missing teeth, and the anatomy of the hard and soft tissue. Although, conservative prosthodontic rehabilitation is the treatment of choice until growth has ceased, conventional approaches like removable partial denture do not usually satisfy the needs of a growing patient. This drawback can be countered by dental implants. Till date, there has been lot of ambiguity about this treatment option. On one hand, implant-supported prostheses are well accepted by young patients, and they may benefit from the blood supply and uncomplicated healing provided by growing bone. On the other hand, the placement of dental implants is susceptible to complications related to growth patterns. This article will present a comprehensive review and recommendations for implant placement in growing children.

Keywords: Growth, hypodontia, anodontia, dental implants, growing children, oligodontia, adolescents.

INTRODUCTION

Edentulism is a term usually related to a geriatric or an ageing patient. But edentulism in children is often associated with trauma, decay, anodontia, congenital or acquired jaw defects of the alveolar bone. Congenitally missing teeth can be seen in patients of Ectodermal dysplasia, Cherubism, Reiter Syndrome, Ellis Van Crevald Syndrome etc. Loss of teeth in children not only causes functional impairment but also leads to social-psychological consequences.[1] Missing teeth in young patients have a negative impact on their emotional status, social relationship, speaking, smiling and overall appearance.[2] Henceforth, these patients require complete oral rehabilitation even before the skeletal and dental maturation has occurred.

In such cases, the main principle is to strive for establishing a good aesthetic, functional and psychosocial state with minimal replacement of the missing teeth by prosthetic treatment. Removable partial denture is the first and most common treatment of choice. However, these prosthesis have their disadvantages as they may increase the residual alveolar bone resorption, periodontal problems, and secondary caries in the remaining teeth.[3] Then, the second option is the fixed dental prosthesis which is also contraindicated in growing children because of larger pulp horns in recently erupted permanent teeth and growth retardation of the jaw if it crosses the midline. However, several new treatment modalities have been introduced

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during the last few decades, important among them being the dental implants.

In adult and elderly patients, the success of implant depends on the bone quality and quantity, treatment planning, sound surgical technique, optimal restorative prosthesis and maintenance of good oral hygiene. However, in children and adolescents, the outcomes are less predictable due to ongoing dental and skeletal growth and related growth spurts of maxillary and mandibular arches.[4] Growth is a dynamic process with stable pattern of changes resulting in the increased physical change of mass during the course of development. So the impending growth is an important factor before planning and commencing implant placement in young patients.[5] Therefore, the aim of this review article is to discuss and determine placement and effectiveness of dental implants in children and adolescents taking into account the jaw bones development and the continued eruptive movement of teeth even after reaching the occlusal contact.

Review of literature

A thorough review of available articles published from 1963 to 2019, was done using the terms dental implants, ectodermal dysplasia, growing children, oligodontia, anodontia. Articles published in languages other than English were excluded.

Sr.No.	Year	Authors	Implications /Results
1.	1963	Bjork[6]	Implanted pins in the jaws of children for longitudinal cephalometric studies and reported that pins in the path of erupting teeth were displaced and those placed in resorptive areas were lost. Pins placed in areas of appositional bone growth became embedded.
2.	1966	Jones BH et al[7]	Illustrated 3-4 mm of maxilla height increase during primary teeth eruption, and exfoliation process. The actual increase of dental height (about 5-6 mm) is between the age of 5 and 15. Therefore, the mutual effects of implant use and dental alterations are unpredictable during childhood.
3.	1977	Shaw WC[8]	He reported that the dramatic growth changes occurring in infancy and early childhood were not conducive to the maintenance of implants.
4.	1993	Oesterle et al[9]	Compared dental implants to ankylosed primary teeth and documented that ankylosis arrests both dental eruption and alveolar bone formation in the affected area.
5.	1993	Ledermann et al[10]	In their 7 year follow up study, the major complication reported was the failure of dental implants to respond to the vertical growth of adjacent teeth and alveolus due to ankylosis.
6.	1993	Smith RA et al[11]	Implant use in children with ectodermal dysplasia is a treatment of choice, since its placement in the mandibular anterior region of a 5-year-old patient did not affect adjacent tooth buds.
7.	1994	Cronin et al[12]	Authors discussed rotational growth of the mandible as related to implants in children with a strong rotational growth pattern resulting in submergence of the implant.
8.	1994	Mehrali MC et al[13]	According to the 1988 National Institute of Health consensus Development Conference on Dental Implants

			at Bethesda, pediatric patients with ED could benefit from the use of dental implants.
9.	1996	Brugnolo et al[14]	They reported the infraocclusion of implants placed in patients aged 13 to 14.5 years, secondary to vertical growth, and prosthesis was redesigned.
10.	1996	Bergendal et al[15]	Stated that implants must be placed when growth is almost complete, except for rare cases of total aplasia as in ED.
11.	1996	Westwood RM et al[16]	Implants placed in the maxillary anterior region have angulation changes, and hence less risk of submersion. This is because there is less bone growth vertically and implants are placed immediately after or within few months of tooth removal to reduce loss of bone.
12.	1997	Guckes et al[17]	Described a case of 3-year-old patient with ectodermal dysplasia in which dental implants located in the mandible and maxilla have not moved despite growth.
13.	1997	Dietschi D et al[18]	Implant placement in children younger than 16–18 years must be avoided.
14.	1999	Kearns et al[19]	Did not find evidence of restriction to transverse and sagittal growth due to implant use in children with ectodermal dysplasia. Prosthesis remodeling was necessary in some patients secondary to implant submergence.
15.	2000	Op Heij et al[20]	Implants inserted into pediatric patients do not follow the regular growth process of the craniofacial skeleton and are known to behave similar to ankylosed teeth, resulting in both functional and esthetic disadvantages.
16.	2003	Rossi and Andreasen[21]	Implants could interfere with the position and the eruption of adjacent tooth germs, thus resulting in potential severe trauma to the patient.
17.	2003	Prachar P et al[22]	Presented the results of a 5-year study on the use of cylindrical or screw implants in adolescents of age 15–19 years. Regardless of the criterion used, the rate of success was always higher than 96% over the 5 years of study.
18.	2006	Sharma A[23]	Discussed the indications for implant placement in growing child. He however suggested that the decision for implant placement is not only based on growth but also on number and location of missing teeth.
19.	2007	Kramer et al[24]	Recommended the insertion of implants in those pediatric patients who suffer from extended syndromal hypodontia, such as seen in ED. The most suitable site for insertion seems to be the anterior mandible; insertions in the maxilla should be avoided or at least should not cross the midline.
20.	2012	Hekmatfar S. et al[25]	Reported two cases of children of ectodermal dysplasia with anodontia in which oral rehabilitation was accomplished with removable acrylic prosthesis. They

			discussed the most common treatment plan is the removable prosthesis. When implant therapy is indicated, the main problem is that if bone atrophy progresses in these already alveolar bone deficient patients, implant placement may not be possible without bone grafting.
21.	2017	Knobloch LA et al[26]	Reported early implant placement in a 9-year-old boy with ectodermal dysplasia and the transitional treatment completed throughout skeletal maturation over the course of 13 years to achieve definitive rehabilitation. Early implant placement provided the benefit of a functional mandibular prosthesis assisted by 2 anterior implants throughout growth.
22.	2019	Bohner et al[27]	In the patients with ectodermal dysplasia, the minimum age for placement of dental implants was 3 years old, and patients with dental trauma it was 10 years old.

Growth of the jaw bones

The growth of maxilla and mandible is multidirectional i.e it does not happen uniformly in one plane but happens along anteroposterior (sagittal), vertical, and transverse planes. Also, it follows a distinct chronology, with growth completion first in a transverse plane, then sagittal and finally vertical. The dental implants follow the displacement of the entire bony complex (via sutural growth) but not drift or bone remodelling.[20]

Growth of the maxilla

The midface grows in a downward and forward direction relative to the anterior cranial base, with maxillary growth occurring as a result of passive displacement and enlargement. During the early years of growth, passive growth is the predominant factor, whereas growth from the enlargement of the maxilla itself becomes the major factor after 7 years of age.[4] According to Bjork, the overall development of the middle part of the face is in downward and frontal directions and is related to the skull base that is mostly inactive up to the age of seven. However, during 7-15 years of age the main factor for anterior displacement of naso- maxillary complex is the growth of maxilla and nasal joints.[6]

Transverse growth

The lateral growth of the maxilla is controlled mainly by the growth of the middle joint of the palate (mid – palatal suture), which is an important growth area, the growth of which is 3 times more in posterior region than anterior.[28] The inter canine distance changes only little after the age of 10. Early placement of implant in the central incisor region can give rise to a diastema with the adjoining teeth resulting in subsequent shifting of the midline to the implant side.[20] Some studies have shown that transverse problems are not reported in implants placed in the anterior maxilla even as early as 9 years of age.[29] The midpalatal suture usually closes after the eruption of the second permanent molars (from 15 to 27 years). The latter should be kept in mind while planning the placement of midpalatal implant as anchorage for orthodontic appliances.[20]

Sagittal growth

The maxilla increases in length due to both sutural growth (sutures of the palatine bones) and bone apposition at the maxillary tuberosities and is complete by the onset of puberty, with subsequent growth occurring primarily in the vertical plane. When the maxilla is placed downwards and forwards during sagittal growth, upto 25% of the displacement is lost by resorption in the anterior region. This could result in an implant losing labial bone gradually.[4,20,28] Teeth also show a mesial drift. The canine to first molar area (lateral segment) moves an average 5mm mesially between 10 and 21 years of age but the maxillary incisors move only 2.5 mm buccally, causing crowding

due to loss of space. An implant does not follow this path of tooth migration. Thus an implant in the lateral segment could stop the mesial drift resulting in an asymmetrical arch while an implant in the frontal region will be positioned palatally with time.[20]

Vertical growth

The vertical growth of maxilla occurs by both displacement (growth at sutures) and drift i.e. the vertical growth of the maxilla occurs by resorption on the nasal surface and deposition on the palatal and alveolar surfaces.[20] The latter will compensate for rotary motion along posterior maxilla.[6,29] The maxilla is displaced downwards away from the cranium, by growth in the orbits and by increase in size of nasal cavity and maxillary sinuses.[20] This vertical growth continues beyond the age at which transverse and sagittal growth cease. In girls, adult levels of vertical growth are reached at 17 or 18 years of age and somewhat later in boys. Between 9 to 25 years, the maxillary incisors will move about 6mm downwards and 2.5 mm buccally. Hence, an early placement of an implant will position it in the nasal floor after puberty while the permanent teeth have moved down.[20]

Growth of the mandible

The growth of the maxilla is more closely related with growth of overall stature whereas the growth of mandible is more closely related with growth of the cranial structures.[4,20] Therefore during adolescence, there is greater anteroposterior growth of mandible which converts the more convex profile of the child to a more straight adult profile.[20] The studies of Bjork[6] using metallic implants showed that the mandible rolls forward, with apposition below the symphysis and resorption below the gonial angle, and tends to rotate along the center of rotation, which is influenced by direction of condylar growth. So in girls, the growth of mandible is completed by 14 to 15 years of age while for boys it is usually completed by 18 years.[20]

Transverse growth

The transverse growth of the mandible occurs primarily in the posterior region, whereas the width in the anterior region stabilises relatively early before the eruption of deciduous teeth.[4] The transverse growth in the mandible completes very early because of the closure of the symphysis in the 1st year of life, and only limited changes occur later through remodelling which makes anterior mandible most suitable place for early implant placement. Posteriorly, there is resorption of the bone lingually and deposition buccally that leads to remodelling.[29] This pattern of bone growth may bring about lingual positioning of the implant in case it is placed early in the posterior region.[20]

Sagittal growth

The sagittal growth of the mandible is through endochondral growth in the condyle and a remodelling of the ramus of the mandible that extends the length but has no impact on the shape of the body of the mandible as such and on implants eventually. The body of the mandible prolongs in an anteroposterior direction mainly through resorption at the ventral site of the ramus and bone apposition at the dorsal surface which accommodates the eruption of first, second and third molars.[20,28]

Vertical growth

Growth in the vertical dimension occurs by the apposition at the dentoalveolar complex during tooth eruption and by rotation of the condyle that appears to displace the mandible downward and forward from the cranium though it is growing upward and backward. This rotation is important for implant placement because the difference in compensatory amount and direction of incisor eruption could affect the relationship of the implant to the adjacent tooth. The implant itself cannot make compensatory positional changes either vertically or labiolingually.[20,28,29]

Deviating facial types: Short and Long face syndrome[20]

From an esthetic point of view, the population can generally be divided into normal, short or long facial types. Even after adulthood, the distinct facial types keep developing in different

ways, showing phenomena that may jeopardize the placement of implants even after puberty. In orthodontic literature, the short facial type is described as: horizontal grower, forward rotator (mandible) and /or skeletal deep bite. Similarly the long face type is described as: vertical grower, backward rotator and / or skeletal open bite. This will be discussed under the syndromes viz. the short face syndrome (SFS) and the long face syndrome (LFS).

Growth differences in relation to the facial types[20]

Maxilla

The SFS group shows more growth in the transverse direction (1.5 mm versus 0.3 mm for LFS) at the midpalatal suture because of late closure. Also in case of a narrow maxilla (as often seen in LFS) the alveolar process grows more in height, while in the case of a wide jaw (as seen in SFS) there is far less increase in height. In comparison to the normal face, the direction of growth of the maxilla will also differ in the two facial types. The dentoalveolar complex of maxilla undergoes rotation in relation to the cranial base because the teeth try to follow the rotating mandible through the dentoalveolar compensation mechanism. This rotation is forwards in SFS adolescents and backwards in LFS adolescents. Since the tooth movement in horizontal direction in the maxilla is greater for the short face type, the implants in the anterior region will eventually drift more palatal compared to the natural dentition, whereas in long face type it is the increased vertical movement of the natural dentition that can create a problem.

Mandible

The facial types show variation in the anteroposterior and vertical growth of the mandible. Because of the mesial drift in the SFS types, anterior implants will be more lingual as compared to the natural dentition, whereas in LFS types the mandibular frontal region will gradually rise lingually so implants will be shifted towards the labial vestibule. SFS children/ adolescents show a more vertical growth in premolar - molar region which could lead to infraocclusion of the implant, whereas LFS children/adolescents show more vertical growth in the anterior region which leads to infraocclusion of an early placed implant in that area.

Growth pattern based on gender

Females complete most of their adolescent growth by 15 years of age and males continue their growth in their early 20s therefore changes in implant position can be observed in the male patients less than 25 years of age. There is 20% increase in maxillary depth and 26 % increase in mandibular depth in males between 15 – 25 years, also mandible is positioned 30% forward.[30] Females show small changes in growth between these ages. Cronin et al[31] observed that placement of implants during the active growth period may lead to displacement or malpositioning of implants by continued growth and therefore may require removal or replacement. Implants placed after the age of 15 for girls and 18 for boys show good prognosis.

GROWTH ASSESSMENT

Chronological age is not a true indicator of growth cessation since there is a wide range of pubertal growth spurt in boys (11–17 years) and girls (9–15 years).[28,29] A reliable assessment of growth cessation can be obtained from cephalometric radiographic examination. Serial cephalometric radiographs are taken 6 months apart, and their tracings are superimposed to ensure that no growth has taken place. Although it is the most reliable method, but it takes a lot of time as one has to wait for 6 months for another cephalogram which further delays implant insertion.[20,29]

Another accurate way of determining skeletal age is to take a hand wrist radiograph and compare it to a standardized atlas.[20,29] Three quick indicators of growth completion are the appearance of adductor sesamoid of the thumb, capping of the epiphysis of the middle phalanx of the third finger and fusion of the epiphysis and diaphysis of the radius.[31,32]

As the skeletal growth of the long bones is complete, facial growth too stops, or it is safe to assume that it is near completion and implants

can be safely placed.[31] It is also advisable to take the growth pattern in relation to different facial types (SFS or LFS) into consideration.[20]

Quadrant wise recommendations for implant placement[5,20,21]

Region	Considerations	Recommendations
Anterior maxilla	-High probability of trauma and missing teeth -Mid palatal suture remains open up to puberty -Premature placement of implant can lead to repeated lengthening of the transgingival or transmucosal part (increase in abutment length)	Implant placement must be delayed upto 15 years in girls and 17 years in boys
Posterior maxilla	-Growth three times more than anterior region (rotational development and mesial drift of molars) -Resorption in sinus and nasal floor and deposition in dentoalveolar region -Load bearing area	Implant placement must be delayed upto 15 years in girls and 17 years in boys
Anterior mandible	-Early closing of symphysis joint in the first 2 years of life -Main transverse and sagittal growth is completed relatively early -Implants with natural teeth are not advisable due to significant compensatory change in dentition	Potential for early implant placement before the skeletal maturation (6years and above)
Posterior mandible	- Significant changes occur both in the alveolus and the mandibular border as the mandible undergoes rotational growth -Load bearing area	Implant placement must be delayed upto 15 years in girls and 17 years in boys

Indications and contraindications of implants in children and adolescents

Indications:[4,31,33]

- Children with congenital disorders (ectodermal dysplasia, nonsyndromic hypodontia)
- Patients with cleft of the alveolus and palate.
- Children having acquired absence of teeth (teeth lost as a result of dentoalveolar trauma and tumour resection).

Contraindications:[4,31,34]

- Presence of adjacent primary teeth
- Pre- pubertal age group.
- Individuals with pubertal growth spurts
- Inadequate mesiodistal space
- Inadequate quantity and quality of bone
- Inability to maintain oral hygiene
- Unrealistic expectations of patient or parents

DISCUSSION

In completely and partially edentulous patients, use of implants has enabled the dentist to rehabilitate patients to a more normal masticatory function which can help the patient to live an improved lifestyle. Treatment of growing patients with implants is very critical due to complications following their premature placement. The impact that a bone supported prosthesis might have on facial growth or, conversely, how growth might influence the

longevity and esthetics of the implant prosthesis is not very clearly known.[35]

Integrated implant in maxilla or mandible behaves like an ankylosed tooth that is, they remain stationary and do not erupt together with adjacent teeth.[19] In failing to move together with erupting teeth, implants were found to inhibit local growth and development of the alveolar process. This point of concern has been responsible for the limited use of implants in the growing children.[23] There are two subsequent possibilities, first is the danger of implants becoming embedded, relocated, or displaced as the jaws grow and second is the rigid prosthesis attached to implants bridging a growing area inhibiting further growth. To compensate the latter, design changes must be incorporated into such prosthesis to allow for growth changes.[1,35] When treating a child certain important factors to be considered apart from growth are the missing tooth, dentition present, residual space between the teeth present in the arch, amount of alveolar bone, and the timing of implant placement.[36]

Post-operative pain/paresthesia, mobility or peri-implant radiolucency related to implants has not been reported in most of the review articles, which indicates the best possible osseointegration in growing children.[37] Infraocclusion or submergence is the main drawback reported in majority of the implants placed in the age group of one to thirteen years. It disrupts carefully constructed occlusal relationships and leads to compensatory eruption of opposing teeth and tipping of adjacent teeth. Also a vertical discrepancy develops between the mucosal margin of the implant and the gingival margins of adjacent teeth.[38]

Several clinicians have been able to achieve a successful implant treatment in children when a multidisciplinary approach is incorporated. For appropriate treatment planning, the child patient is seen by the paediatric dentist at a very young age and remains under his care for a long period of time. Ryda et al[39] suggested that all the clinical judgment and treatment for children should be performed according to the United Nations Convention on the Rights of the Child. Child's development physically as well as psychologically should be respected while planning the treatment.[40] Children of age six years and above can undergo implant placement in mandibular anterior region in cases of anodontia whereas children of around 3 years of age should be treated only by removable prosthesis as recommended by National foundation for Ectodermal Dysplasia, USA.[40]

The timing of implant placement in growing patients was discussed at a Scandinavian Consensus Conference in Sonkoping, Sweden, where there was a general agreement that implant placement should be postponed until skeletal growth is completed or nearly completed in normal adolescents. In the individual with oligodontia or anodontia, however, earlier intervention could be indicated, especially in the mandible.[1] It is the opinion of many authors that implants should be placed not immediately, but close to exfoliation or extraction of persisting deciduous teeth in order to preserve alveolar bone.[41] The safest time to place implants seems to be during the lower portion of the declining adolescent growth curve at or near adulthood that can be determined by cephalographic radiographs, serial measure of stature, or hand-wrist radiographs.[35]

Implant success will depend upon the functional status of mastication and phonetics, esthetic aspects, emotional and psychological well-being and child's compliance to implant treatment and implant hygiene.[35] If the goals of treatment planning favour implant use before skeletal maturation, parents must be informed about benefits and possible complications, and careful attention must be given to prosthesis design.[1] And if the clinician cannot keep the patient under regular observation or is not interested to frequently change the transgingival component the implant placement should be avoided.

CONCLUSION

Dental implants can serve as a successful mode of oral rehabilitation in children and adolescents if carried out with the help of systematic treatment planning which can lead to desired esthetic and functional results especially

keeping in mind the growth considerations. It is recommended to delay the implant placement till the growth spurts are completed except for the mandibular anterior region where implants can be placed before skeletal maturation.

Although long-term follow-up are stated by many articles, the results are mainly supported by case reports. A detailed analysis of patients by growth-phase is required to better understand the relations between the growth of the jaw and complications of implants. Further studies are required to define a specific protocol for the placement of dental implants in growing jaws.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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