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FINAL DISSERTATION FOR

THE DIPLOMA OF DOCTOR OF DENTISTRY

THEME:

ORAL IMPLANTOLOGY IN CHILD (SYSTEMATIC REVIEW)

Presented by:

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بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ. وَعَلَّمَ آدَمَ الْأَسْمَاءَ كُلَّهَا

"And He taught Adam all the names." (Surah Al-Baqara, verse 31)

This noble verse serves as a reminder that all knowledge and all truth originate from God.

There are moments when words become prayers and the lines, we write become memory. This work is not merely the result of my intellectual effort, but the fruit of an inner journey, nourished by patience, faith and love.
It reflects countless silences, hopes carried in quiet perseverance and the steadfast support of those whose kindness has never faltered.

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Everything I am and everything I hope to become, is rooted in you. My journey has been filled with challenges, doubts and long nights, but through it all, your love has been my shelter. Your voices echoed in my mind when I needed courage and your silent prayers gave me strength even when I didn't realize it. I carry your values, your hopes, and your sacrifices with me in every step I take. You never asked for anything in return, yet gave me everything: time, patience, trust and unconditional love. I have no words strong enough to repay what you've given me, but let this work be a quiet offering — a small piece of what your care has built in me. From the bottom of my heart, thank you. My success is yours as much as it is mine.
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May Allah protect you always and keep you by my side.

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Thank you for your love, support, and constant encouragement.I love you.

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AED: Anhidrotic Ectodermal Dysplasia

CBCT: Cone Beam Computed Tomography.

ED: Ectodermal Dysplasia

HAS: Haute Autorité de Santé

HED: hypohidrotic ectodermal dysplasia

MDIs: Mini Dental implants

OMS: l'Organisation National de la Santé

OVD: occlusal vertical dimension

RPD: removable partial denture

I. *INTRODUCTION*

Children are different from adults in terms of physical, emotional, and psychological maturation. Childhood is the most significant period of growth and development. Therefore, carrying out dental care, such as an extraction or a pediatric prosthesis, requires a delicate and thoughtful approach.

In pediatric prosthetics, the replacement of missing teeth due to agenesis or acquired trauma often requires oral rehabilitation even before the completion of skeletal and dental maturation. The most common treatment option is a removable partial denture (RPD), although this solution comes with several complications, such as a high risk of dental caries, periodontal problems, and increased chances of residual alveolar bone resorption. Furthermore, the loss of teeth leads to reduced oral function and a lack of normal alveolar growth, along with aesthetic concerns that can hinder the psychosocial development of the child.

Implantology has made significant progress in recent years, achieving a success rate of over 90% in adults. It has become the treatment of choice for adventurism. However, dental implants in children are still a relatively new and cautious approach due to two main concerns:

(1) In a growing child, the presence of implants over several years of facial development poses a risk of the implants becoming embedded, displaced, or misaligned due to the dynamic nature of jaw growth.

(2) The second concern is the potential impact of the prosthesis on normal jaw development.

Oral implantology in children remains a controversial topic. While some practitioners advocate for its use, many others argue against it.

This is why the subject has attracted our interest and motivated us to explore recent developments. The main research question is:

"Why is oral implantology an important solution in children?"

The principal objective of this review is to evaluate the clinical feasibility of dental implants in growing children. It also aims to establish the correlation between maxillary growth and the suitability of oral implantology in children, and to provide recommendations for pediatric oral implantology.

1. Generalities about children and implants

Children are individuals who, of course, belong to the same society as adults and play an essential role within it. However, in the medical field, they are still too often viewed as "little adults." This perspective is inaccurate — both in terms of the illnesses they experience and the treatments they require. It is crucial to adopt a holistic approach when caring for children, as they are developing beings.

Children's growth and development create unique conditions that influence how medical devices should be used. Understanding these general characteristics is essential before considering any type of treatment.

1.1. Definition of a Child:

In the field of dentistry, a child is generally defined as an individual aged from birth to 18 years, during which major phases of growth and craniofacial development occur. During this period, temporary teeth emerge in early childhood and are gradually replaced by permanent teeth between the ages of 6 and 12**(1).**

In pediatric dentistry, a child is typically defined as an individual who is in the developmental stages of growth — generally from infancy to adolescence. Since there is no universally fixed age range, pediatric dentists commonly treat children from birth to 18 years**(2)**.

1.2. Child Growth:

Child growth is the process of gradual and orderly development characterized by an increase in body size, changes in shape, and the functional maturation of tissues and organs. This process is influenced by genetic, nutritional, environmental, and hormonal factors, and is essential for achieving physical and physiological maturity.

Growth is an irregular phenomenon, with phases of acceleration and deceleration. It is therefore important to evaluate the remaining growth potential, which is done by placing the child on a growth curve **figure 1(3)**.

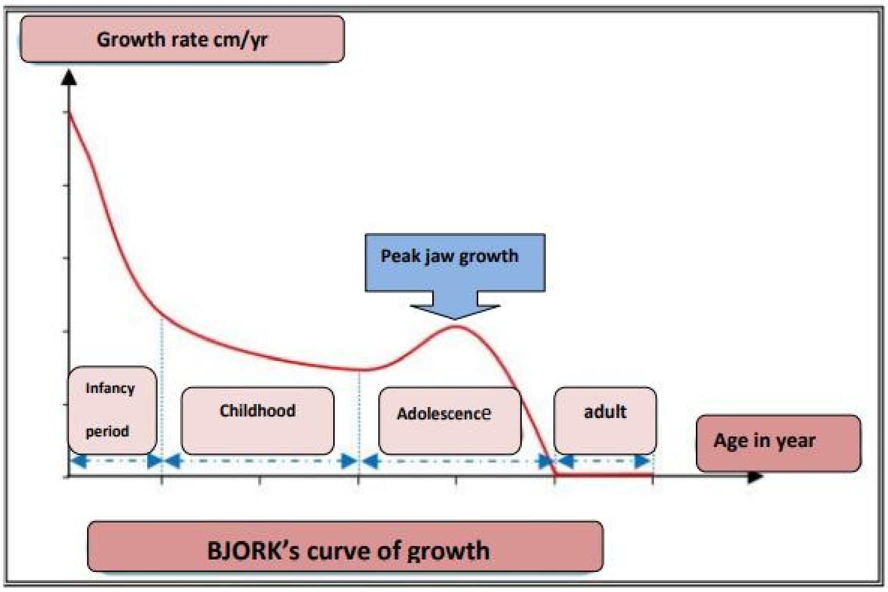


Figure 1: Average Curve of Growth According to Björk (3)

- **Interpretation of the Björk Growth Curve figure 1:**

1) Infancy (0 to 2–3 years):

Growth begins at a very rapid rate at birth but slows down and stabilizes around 2 to 3 years of age.

2) Childhood (2 to 10–13 years):

Growth continues at a steady but slower rate. During this stage, there is a period of minimal growth just before puberty, known as the pre-pubertal minimum. This is followed by a noticeable acceleration in growth, leading up to a peak—typically around age 11 for girls and 13 for boys.

3) Adolescence (12 to 15 years):

There is a marked increase in growth rate during this phase, reaching a peak, after which it gradually slows down. Growth usually ends around 16–18 years in girls and 18–20 years in boys. This stage also includes the development of secondary sexual characteristics, as well as significant increases in height and muscle mass **(3)**.

- **Peak Jaw Growth in children and adolescents:**

Peak jaw growth is a period of significant acceleration of bone development, generally occurring between 10–15 years in girls and 12–17 years in boys. This period is marked by rapid development of the facial structures, including the upper and lower jaws, as well as the eruption of permanent teeth(4) .

- **Facial Growth Pattern:**

The face is composed of two functional floors:

The maxillary floor (upper jaw)

The mandibular floor (lower jaw)

Their development is interdependent. Facial growth is continuous from birth through adolescence. It is particularly active during early life and puberty. Growth is later and longer in males, while in females, growth is nearly complete by the age of 15. In males, it may continue beyond 19 years of age **(5)**.

- **Understanding Growth: Key Concepts**

To understand growth in any area of the body, especially the maxillofacial region, one must consider the following concepts:

- **Growth sites:** specific anatomical zones where active bone growth occurs
- **Types of growth:** appositional, endochondral, sutural
- **Determinant factors:** genetic, functional, and environmental influences

- **Functional elements influencing growth:**

Functional stimuli play a critical role in maxilla-facial development. The most important include:

1) **Breathing:**

Normal nasal breathing promotes harmonious development of the maxilla. In contrast, chronic mouth breathing may result in narrowing of the upper jaw and posterior mandibular rotation, leading to facial dysmorphies.

2) **Masticatory Forces:**

These forces stimulate bone apposition, especially in the alveolar processes and the ascending ramus of the mandible.

3) **Swallowing:**

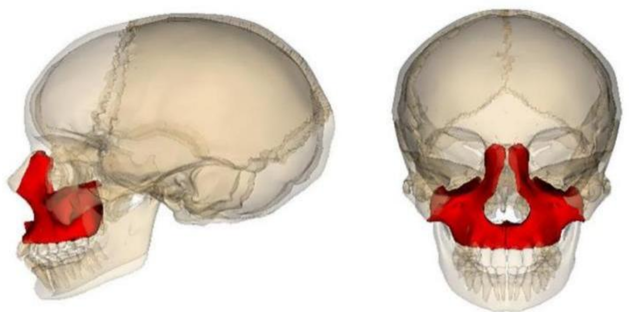
Atypical swallowing (e.g., with tongue interposition) disrupts muscle balance, influencing both tooth positioning and jaw development.

4) **Tongue Position**:

A low or advanced tongue posture can alter the palatal shape and transverse jaw growth**(3).**

1.2.1. Growth changes seen in maxilla:

The maxillary bone is an even bone, it forms with that of the opposite side the skeleton of the jaw superior. Voluminous but light due to the presence of an airy cavity: the maxillary sinus. It is involved in the formation of the oral, nasal, and orbital cavities. It is located above the oral cavity **figure 2 (6).**



LATERAL VIEW **ANTERIOR VIEW**

Figure 2:The maxilla location(7)

The upper jaw develops from the maxillary process of the first pharyngeal arch, as early as the 4th week of embryonic life. Its ossification is membranous and begins around the 7th week. It participates in the formation of the palate, nasal cavities and face **(8)**

It is triangular pyramidal in shape **figure 3***,* this complex bone has:

- Three faces: an upper or orbital face, a postero-external face, an anterolateral face .
- An internal base that forms the lateral wall of the nasal cavities.
- A truncated external vertex(9).

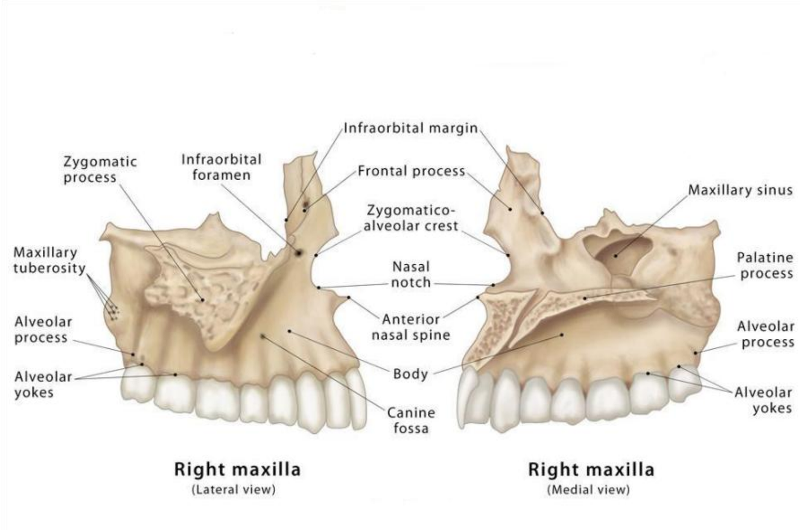


Figure3:**The maxilla's anatomy(10)**

At birth, the maxillary bone is poorly developed. The palate is located under the floor of the orbits. It widens through growth in the intermaxillary suture, junction between the right and left maxillary bones, and to the bone apposition on the tuberosities. The "down" by bone remodeling: resorption on the upper surface of the palate and apposition on its underside(11).

In the maxilla, the alveolar processes are located at the lateral and anterior limits of the palate and develop with the teeth in a vertical drift motion **figure4**. The growth of alveolar processes participates in vertical, sagittal growth (anteroposterior) and transverse (right-left) of the face. It has a compensating role of possible misalignment between the bone bases and an adaptation role to the mandible, independent of the skull. The growth of alveolar processes is done by remodeling and connects the craniofacial growth at dentition(11).

Figure4:Lower view of maxilla(12)

1.2.1.1.*Transverse growth of maxilla:*

Transverse maxillary growth refers to the increase in the width of the upper jaw, especially across the molars and palate, primarily during childhood and adolescence.

It corresponds to the lateral enlargement of the maxilla through the opening of the medial palatine suture ***(13).***

This growth is active from early childhood to late puberty (about 12-15 years). After this period, the medial palatal suture begins to ossify and gradually closes**(14)**

Due to adaptive changes within the dental arch, as seen in **figure 5** this increase is thre etimes more posteriorly than anteriorly, although the transversal increase in widthbetween t he posterior teeth is reduced **(15)**

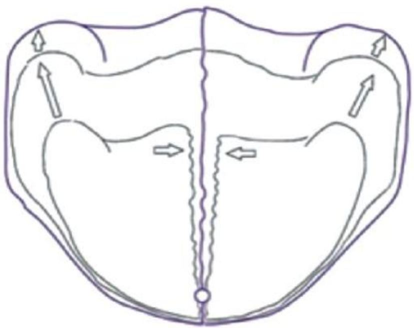


Figure 5 : Horizontal growth of maxilla (15)

Transverse maxillary growth experiences a significant acceleration during puberty. Studies indicate that the average increase in maxillary bone width ranges from 5.8 mm in females to 7.5 mm in males between the ages of 6 and 18 years. This growth is most pronounced between the ages of 6 and 13 years, with a peak growth spurt occurring at approximately 14 years in females and 15 years in males (16).

The eruption of permanent teeth plays a crucial role in maxillary width changes. The transition from the primary to the permanent dentition is associated with an increase in maxillary arch width. This period marks a significant phase in the development of the transverse dimension of the maxilla(17)

Adult males typically exhibit a greater maxillary width compared to females, with differences approximating 5 to 7 mm during late adolescence. This disparity is attributed to males having a longer and more intense growth period during childhood and adolescence.

Males enter the adolescent growth phase later than females, contributing to this difference (18)

1.2.1.2.*Vertical growth of maxilla:*

The vertical growth of the upper jaw corresponds to the increase in the height of the maxilla **figure6**, that is the distance between its base (at the level of the nasal bone and cranial sutures) and the occlusal region (teeth) or palatine.

It is done mainly by bone apposition at the craniofacial sutures (especially the fronto-maxillary and zygomatico-maxillary suture) as well as by the development of the nasal septum and remodeling of the nasal floor and palate **(19)**

A retrospective study of a Spanish population found that the vertical growth of the maxilla was more pronounced in prepubescent women, with an average increase of 0.2 mm per year between 8 and 18 years. This growth is particularly significant during the pre-puberty period **(20)**

A longitudinal study estimated that the total vertical growth of the maxilla (measured from Nasion to Premolar) is about 24 mm between 1 and 18 years. Approximately 33% of this growth occurs before 3 years, and 54.9% after 5 years. Girls reach maturity around age 12, while boys reach maturity around age 14 (21)

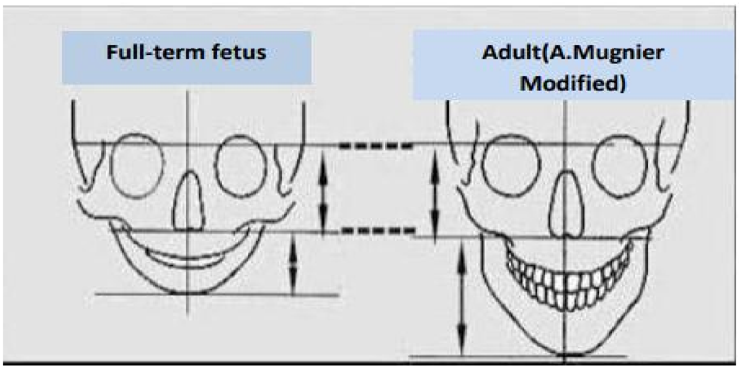


Figure 6: Vertical face growth(22)

1.2.1.3.*Sagittal growth of maxilla:*

Sagittal growth of the maxilla corresponds to development in the antero-posterior direction, that is from the back to the front of the skull.

It is manifested by a projection towards the front of the maxilla, resulting from the secondary displacement of the maxillary bone from the base of the skull, associated with bone growth at the craniofacial sutures (especially the fronto-maxillary suture) and remodeling of the bone surface **(19).**

The maxilla grows sagittal on average 6 to 8 mm between childhood (around 6 years) and late adolescence (around 18 years).

The average growth rate is about 0.5 mm/yr during childhood, with a pubertal peak of up to 1 mm/yr.Growth slows down after puberty and stops around 17-18 for girls and 18-20 for boys **(23).**

Both sutural growth and bone apposition at the maxillary tuberosity contribute to the maxilla's increased length**figure7.**The maxilla's anterior region is comparatively stable.However, up to 25% of the maxilla's forward and downward displacement during growth islost at the anterior site due to resorption **(15) .**

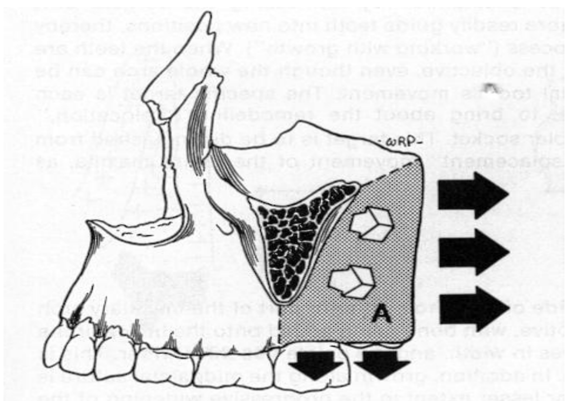


Figure 7:Sagittal growth of maxilla due to tuberous growth(24)

The fronto-maxillary suture contributes to sagittal growth with bone apposition measured at about 0.2 to 0.3 mm/yr during active growth. Other sutures (zygomatico-maxillary, naso-maxillary) also participate, but in a lesser way**(23)**

The maxilla moves forward at a rate of about 0.4 to 0.6 mm/yr during the active growth phase, due to remodeling and bone growth in the nasal floor and **(25)**

Boys have longer and slightly larger sagittal growth (about 1 to 2 mm more in total) than girls, with differences in duration and intensity of growth **(26)**

1.2.2. Growth changes seen in mandible:

The mandible, or lower jaw, is the most voluminous and mobile facial bone of the face, shaped like a horseshoe, consisting of a horizontal body and two rising branches (rami) posterior **figure8 (27)**

The embryonic neural crest cells move ventrally to generate the mandibular prominences, where they develop into bones and connective tissue, forming the cartilage and bones of the mandibular**(28)**

The mandibular body comprises a convex outer face and a concave inner face where several muscles are inserted, including the mylohyoid muscle on the mylohyoid line.It has a mandibular foramen (mandibular foramen) on the medial side of the branch, through which the nerves and mandibular vessels pass**(29).**

The rising branch (ramus) has two extensions:

- The condylar process, which articulates with the temporal bone to form the temporomandibular joint (TMJ).
- The coronoid process, where the temporal muscle is inserted **(30)**

The mandible has two main cavities:

- The alveolar box that supports the mandibular teeth.
- The foramen mentonnaire located on the anterior face, which allows the passage of the nerves and vessels of the chin

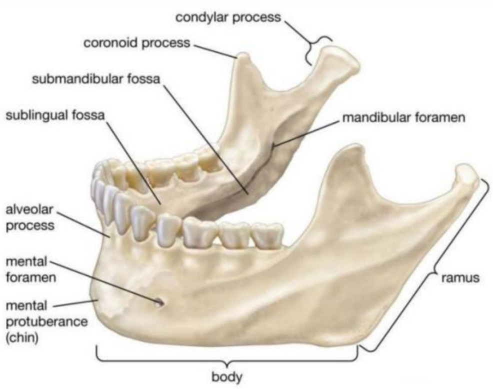


Figure8: Anatomy of mandible(31)

The mandibular symphyseal (or mentonary symphysis) is the anterior medial area of the mandible, located between the two halves of the bone, which are initially separated at birth **figure 9 and 10**.

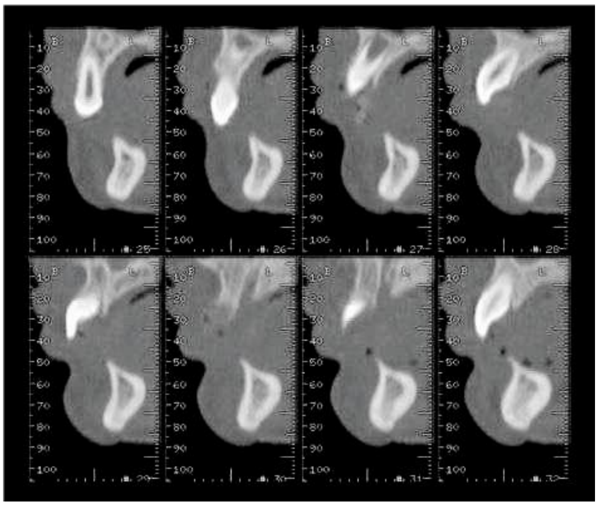


Figure9 :Sagittal symphyseal sections of a 6-year-old child, showing a "teardrop-shaped" image (32)

Figure 10 :Lateral view of the mandiblar symphysis taken by occlusal film(33)

In the newborn, the mandible is made up of two bone halves joined by a fibrocartilaginous suture called mandibular symphysis.

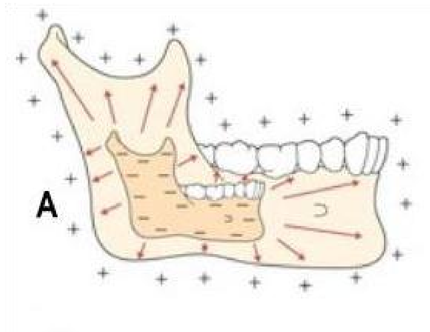
Fusion of the mandibular symphysis ,this suture closes by ossification towards the end of the 1st year of life, forming a single bonefigure 11 (19).

Figure 11:Variation in symphyseal character states across adult primates: superior views of the symphysis in primitive (a: unfused), intermediate (b: partially fused) and derived (c: fused) conditions (34).

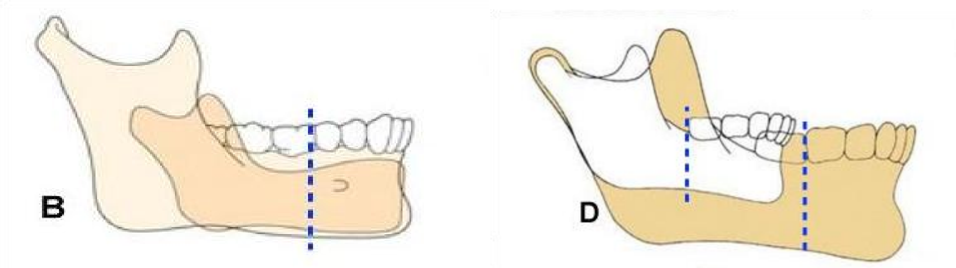
The mandibular and maxillary growth cycles are similar, though not precisely the same.

Compared to the former, which is more strongly associated with increase in stature, the lattice is more strongly associated with the growth of the cranial structures.
This explains why, during adolescence, the mandible expands more sagittally than the m axilla figure 12.

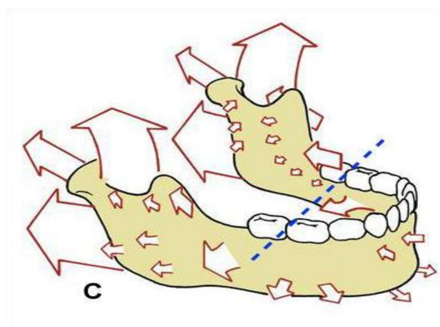
This "differentiated jaw growth" causes the child's profile to become straighter as an a dult instead of more convex.Girls' mandibular growth achieves nearly completion two to th ree years after menarche, usually around the ages of 14 or 15.Though it frequently reaches adult levels by the age of 18, boys growth can continue into their early 20 years (15).



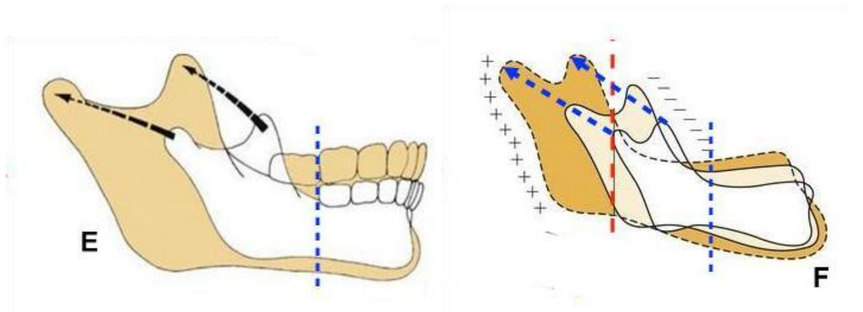
(A) Despite what one might think, this does not represent how mandibular growth occurs. The mandible does not grow equally and at the same time in all dimensions.



(B and D) Comparison of mandible size for a child (6 years old) and adult.

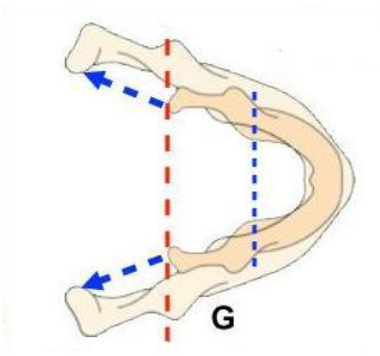


(C) The mandible grows instead through a series of complex 3D bone appositions and resorptions that make it constantly remodel itself until the end of growth.



(E) The growth direction of the mandible is backwards and not forwards but the impression this gives is that the mandible moves forward **(D).**

(F) Comparison of the mandible size at 3 stages of its growth and development. There is remodeling in the anterior part but no significant increase in the length of the dental arches after the first permanent molars are removed.



(G) Upper view compared the mandible of a child and an adult. Although there is growth, it occurs backwards and very slightly in width once the first permanent molars have erupted into mouth

Figure 12: Mandibular growth(31)

On all illustrations, the blue dotted line indicates the length of the anterior arch (in front of the first permanent molars) and this dimension does not change. It is the same when comparing a child's mandible to that of an adult. Growth and development occur mainly behind this line.

The red dotted line indicates the back of the condyles and demonstrates that the most significant changes occur behind this reference.

The black and blue dotted arrows indicate the rearward growth direction of the condyles and rising branches (coronoid apophysis) of the mandible.

1.2.2.1.*Transverse mandibular growth:*

Transverse growth of the mandible refers to the increase in width of the lower mandibular arch during development **figure 13**. Unlike the upper jaw, this growth is limited because the mandible does not have an active median suture. It depends mainly on the condylar growth, the adaptation of the rising branches at the base of the skull and the pronotional growth at the level of the periosteal surfaces. This growth plays a crucial role in the balance of dental arches and occlusion**(35).**

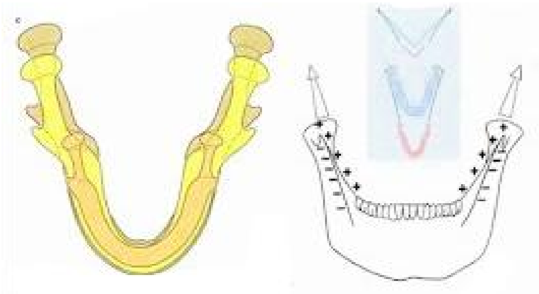


Figure 13:Transversal growth of mandible(15)

Transverse growth of the mandible is a process mainly directed by condyle activity, with an inverted "V" arrangement of rising branches. This growth is manifested by a bony apposition towards the outside, back and top **(36).**

According to Björk, condylar growth is estimated at approximately 1 mm/year outward (per condyle), 2.5 mm/year backward, 3 mm/year in height during the juvenile period, 1.5 mm/year in prepuberty and up to 5.5 mm/year in puberty, with an overall increase in bicondylar distance of about 2 mm/year **(37, 38).**On the other hand, the symphysis mentonaria, anterior region of the mandible, stops any transverse growth from the first months of life, limiting any previous expansion**(36).**

The transverse growth observed in the alveolar region is more moderate: the mandibular intercanine width increases by 2 to 3 mm during mixed dentition and by about 1.5 mm during eruption of permanent canines **(36).**

Overall, transverse growth of the mandible is more pronounced between 6 and 18 years of age, with maximum activity around puberty, then significantly slowing down after 18 years. It concentrates exclusively on the back of the mandible.

1.2.2.2.*Vertical mandibular growth :*

Vertical mandibular growth refers to the increase in height of the mandible, allowing its development towards the bottom and front. This process is essential for the adaptation of the jaw to surrounding structures and dental development **figure 14(11)**

Figure 14: Growth of mandible according to Vertical principle

First, the cartilaginous growth of the mandibular condyle, which is considered a primary growth center, allows the rising branch of the mandible to lengthen through an enchondral ossification process**(39)**Then, the remodeling growth occurs by phenomena of bone apposition and resorption on different parts of the mandibular bone, influenced by the surrounding muscular and functional forces**(40)**.Finally, the increase in height of alveolar processes (where teeth are inserted) also contributes to vertical growth, notably through tooth eruption and bone apposition under the alveoli **(41)**

This vertical growth is not constant but evolves according to the periods of development of the individual **figure 15**. It varies significantly during development: it averages approximately 3.3 mm per year during the juvenile period, slows to around 1.5 mm/year in prepuberty, and peaks at about 5.5 mm/year during puberty. Additionally, condylar growth continues beyond adolescence and into early adulthood (approximately 18–23 years of age)vertical condylar growth varies significantly during development: it averages approximately 3.3 mm per year during the juvenile period, slows to around 1.5 mm/year in prepuberty and peaks at about 5.5 mm/year during puberty(42)

Additionally, condylar growth continues beyond adolescence and into early adulthood (approximately 18–23 years of age)**(42)**

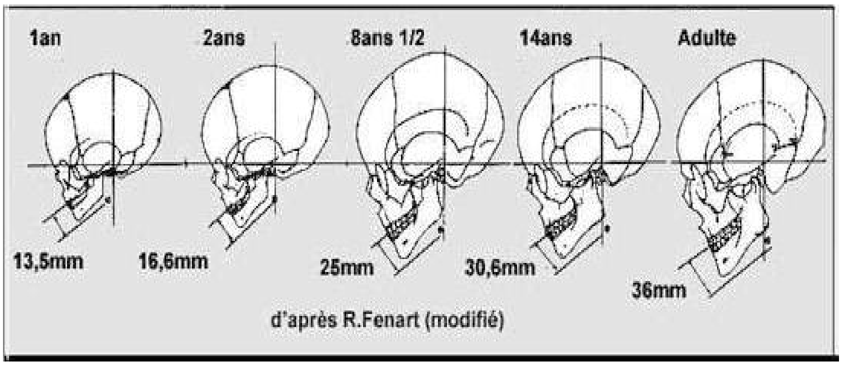


Figure 15: Vertical growth of mandible (22)

The direction of this vertical growth can influence the rotation of the mandible: forward-facing growth is associated with anterior rotation, producing a shorter face and a more advanced chin, While backward growth promotes posterior rotation, often seen in long-faced patients. These phenomena are also influenced by the position and orientation of the condyle in the glenoid cavity**(39)**

1.2.2.3.*Sagittal mandibular growth :*

Sagittal mandibular growth refers to an increase in the length of the mandible, that is, its development forward and backward. This process is essential for the functional and aesthetic balance of the face **figure 16.**

It is mainly done by two mechanisms: condylar growth, with a bone apposition at the back of the condyle and resorption in front, and remodeling growth, by bone apposition and resorption on the surfaces of the mandible **figure17**. In terms of quantity, vertical mandibular growth varies with age. In the juvenile stage, it is about 3.3 mm per year; it slows down to about 1.5 mm per year before puberty, then peaks in growth during puberty, reaching up to 5.5 mm per year. This growth usually continues until 18 to 23 years of age.**(43)**

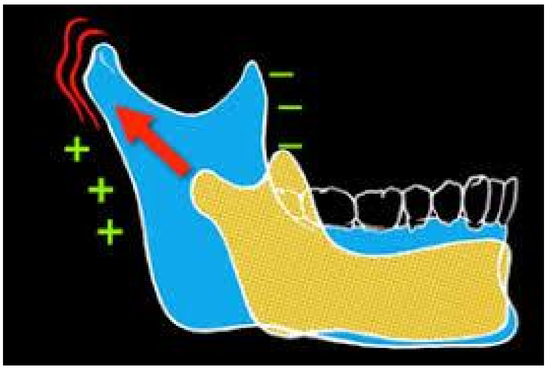


Figure16:Sagittal mandibular growth(31)

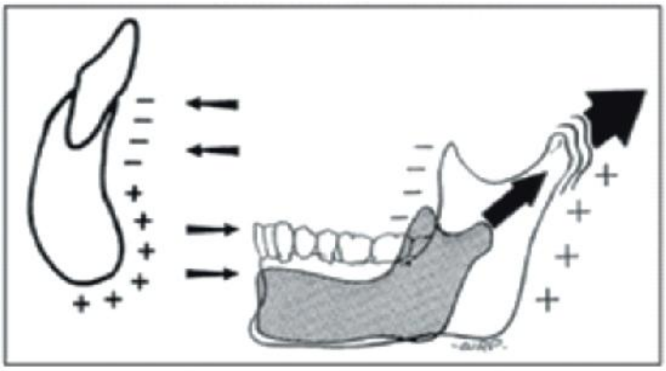


Figure 17: A typical growth pattern of mandibular schematically. midline and ramus transformation(24)

1.3. Assessment of child growth :

Chronological age alone is not a reliable parameter to assess an individual's stage of growth. In general, females tend to reach maturity earlier and progress through developmental stages faster than males. While various techniques are available to estimate growth and biological age, none can accurately predict the exact point at which growth ceases.

Growth assessment can be evaluated through several methods:

- Superimposition of serial cephalometric radiographs: this technique is considered the most reliable for monitoring craniofacial growth **figure 18**. However, it is time-consuming, labor-intensive and may delay implant placement(44)**.**

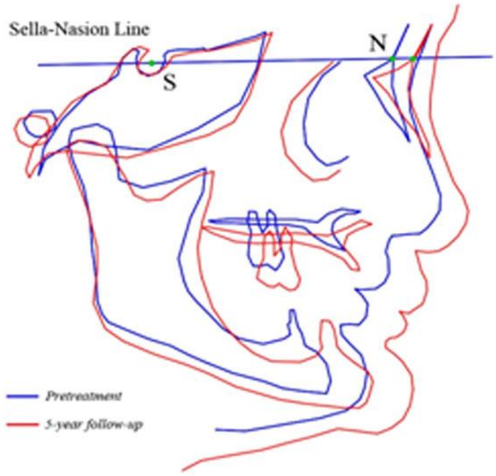


Figure18:**Patient's growth pattern using cephalometric evaluation at 5 years(36)**

It enables clinicians to monitor growth patterns over time by comparing successive images taken at different developmental stages. This technique provides a visual and quanttative analysis of skeletal changes, especially in the maxilla-mandibular complex.

A key parameter in these radiographs is the ANB angle **figure 19,** which reflects the sagittal skeletal relationship between the maxilla and the mandible. When serial radiographs show stability of the ANB angle across time, it suggests that the skeletal relationship has matured, thus indicating a reduced risk of infra-occlusion of implants due to further jaw growth. Conversely, significant changes in the ANB angle over time may indicate ongoing growth. By combining superimpositional analysis with ANB angle measurements, clinicians obtain a more comprehensive understanding of skeletal maturation, which is especially important in children with congenital conditions (e.g., ectodermal dysplasia or cleft lip/palate) where growth patterns may be altered**(45).**

It provides information on:

- Skeletal Class I: ANB ≈ 2° (normal jaw relationship)
- Skeletal Class II: ANB > 4° (maxillary protrusion or mandibular retrusion)
- Skeletal Class III: ANB < 0° (mandibular prognathism or maxillary deficiency)

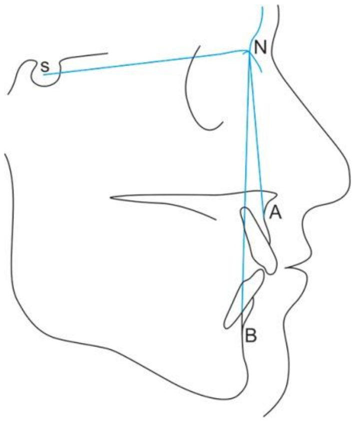


Figure19 :Angle ANB (46)

Hand-wrist radiographs:these provide a general indication of skeletal maturity in adolescent patients. The “capping” stage of the epiphysis corresponds to the onset and peak of puberty, aiding in treatment planning. The optimal and safest time is when the epiphysis of the radius is completely fused with the diaphysis, indicating the end of skeletal growth. Once the skeletal growth of long bones is completed, the facial growth is stopped **figure 20 (44) .**

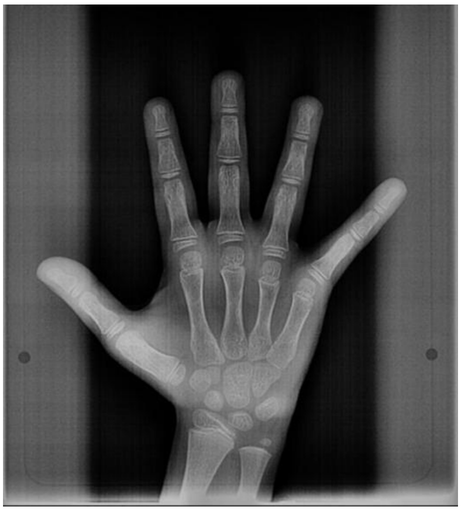


Figure 20:Hand wrist X- ray of male patient (Age 8 years and 6 months) According to standard plates of Greulich and Pyle atlas age could be 10 years(47)

1.4. Dentitions in child:

The human dentition consists of two sets of teeth: the primary (deciduous) and the permanent teeth. These teeth are arranged in two opposing arches: the maxillary (upper) and the mandibular (lower). Each arch can be divided along the midline (mid-sagittal plane) into left and right halves. Teeth are housed in alveolar sockets and anchored to the surrounding bone by the periodontal ligament. A tooth consists of two primary parts: the crown and the root. The clinical crown is the portion visible in the mouth, while the clinical root remains hidden beneath the gum line. From an anatomical perspective, the crown and root differ in structure and the type of hard tissue covering their outer surfaces. The anatomical crown is coated with enamel, whereas the anatomical root is covered with cementum**(48)**

1.4.1. Teething:

is a dynamic term that encompasses all the development phenomena of dental arcades: origin, mineralization, growth, eruption, aging and replacement of teeth. The human dental system consists of two successively: it is diphyodontic.

At the embryonic level, there is:

- **First dental blade:** It depends on the maturation of the dental elements born from the first dental blade. It sets up 32teeth: 8incisors, 4 canines, 20molars (8lacteales, 12 permanent).
- **Second dental blade**: Gives 20 teeth from the second dental blade: 8incisors, 4 canines, 8 premolars. The teeth that belong to the first dentition go ,for some of them, be replaced by the teeth of the second dentition**(49)**

1.4.2. Dentition:

is a term that refers to the set of teeth present in the oral cavity given time. It is used to describe a static state. Humans normally have three successive dentures due to the replacement of temporary teeth by teeth permanent

- **Temporary teeth:** from the age of 6 months to the age of 6 years, the child has only teeth in the oral cavity from the first dentition, and all of these teeth are temporary. They are among20 teeth (08 incisors ,04 canines ,08 molars**(49)**

- **Mixed tooth:** from the age of 6 years (date of appearance of the first permanent tooth) until the last temporary tooth (11-12 years), temporary and permanent teeth coexist in the breast dental arcades. This denture is called mixed .There is 08 incisors ,04 canines lacteal,04 molars permanent,08 molars lacteal). **(49)**
- **Permanent teeth**: from the fall of the last temporary tooth, all teeth in the mouth are permanent. The incisors, canines and premolars are from the second dentition, while that the molars are from the first dentition. There are 32teeth **(49)**

1.5. Edentulism child:

Premature loss of both deciduous and permanent teeth in children can lead to functional issues such as difficulties with chewing, misalignment or delayed eruption of teeth and speech impairments. Additionally, it can affect a child’s appearance, potentially causing emotional distress. This may result in lowered self-esteem, feelings of insecurity and even expose the child to bullying or ridicule.

1.5.1. Definition of edentulism:

Edentulism is the complete loss of all natural teeth, it results from various biological disease processes including dental caries, periodontal disease, trauma and oral cancer. This condition is often associated with multiple comorbidities that can have a substantial impact on an individual's overall health and quality of life **(50)**

1.5.2. Etiologies of edentulism :

There are many causes of edentulism in the permanent dentition of the pediatric population. The earlier they occur, the greater their impact on development

1.5.2.1. ***Dental caries :***

Caries is a “localized pathological process of external origin, occurring after eruption, accompanied by softening of the hard tissues and progressing to cavity formation” (OMS).

The assessment of oral health in schools, for the school year 2023-2024 reports a prevalence of caries of 53.41%. Oral diseases are among the most common non-communicable diseases in the world, according to WHO, about 3.5 billion people suffer from oral problems worldwide **(51).**

1.5.2.2. *Trauma :*

Dental trauma encompasses injuries involving the teeth, specifically the crowns and roots,as well as the surrounding alveolar bone **(52)**. These injuries are typically caused by a direct impact to one or more teeth and/or their supporting structures. Such trauma can result in fractures, displacement, or both, and may also involve the separation or crushing of adjacent tissues**(52)**

The prevalence of dental trauma to permanent teeth is around 15% in the general population. It occurs mainly in boys (69% of cases, versus 31% in girls), between the ages of 12 and 14 (53).

The teeth most involved in dental trauma, in both mixed and permanent dentition, are the maxillary central incisors. They account for 77% of reported cases (53).

Falls are the main cause of dental trauma in mixed and permanent dentition, accounting for over 90% of cases. Shocks related to sporting activity are the second most important etiology, accounting for around 6% of cases (53)

1.5.2.3.*Agenesies :*

According to the French National Authority for Health (Haute Autorité de Santé – HAS), dental agenesis is defined as a "numerical dental anomaly due to the absence of development of one or more tooth buds." Agenesis may be observed in both the primary and/or permanent dentition, but it most commonly affects the permanent dentition. It can be either single (isolated) or multiple.

A. Simple Agenesis and hypodontia:

Hypodontia is defined as the congenital absence of fewer than six teeth (54)
The distribution of hypodontia was described in a systematic review conducted by A.H. Al-Ani (54). According to this study, the prevalence is 5.5% in Europe, 6.3% in Australia, and lower in the Americas. In 80% of cases, agenesis affects only one or two teeth. Excluding third molar agenesis (which affects approximately one in five individuals), the most commonly missing teeth are the mandibular second premolars (3.1%) and the maxillary lateral incisors (1.7%)(55)

B. Oligodontia:

Oligodontia refers to the congenital absence of more than six teeth (either primary or permanent), leading to a vertical deficiency of the alveolar bone. The most commonly affected teeth are the second premolars (15–32%), followed by the maxillary lateral incisors (27%). Less frequently, oligodontia may involve canines, first and second molars (1%).

In the European population, the prevalence ranges from 1 in 625 to 1 in 1,250. Oligodontia may occur in isolation or as part of a syndrome when associated with other clinical signs .Diagnosis is based on clinical and radiographic examination, including panoramic and periapical X-rays (56).

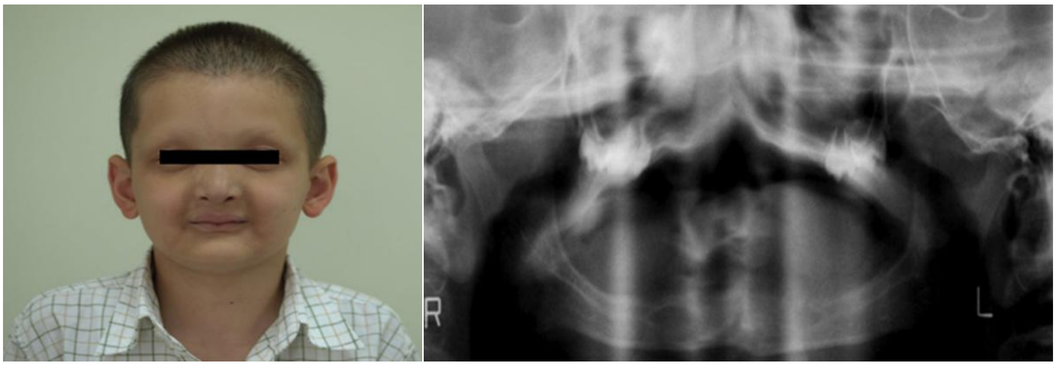
C. Anodontia:

Anodontia is characterized by the complete absence of all teeth. Its prevalence is unknown, as it is an extremely rare condition. It occurs exclusively in syndromic forms and is most often associated with X-linked hypohidrotic or anhidrotic ectodermal dysplasia (HED or AED).
Similar to oligodontia, the absence of teeth in patients with anodontia leads to atrophy of the alveolar bone (57)

- **Ectodemal dysplasia :**

ED is a hereditary disorder first described by Thurman. It affects the development of tissues derived from the ectoderm, such as skin, hair, nails and teeth (58). Hypohidrotic ectodermal dysplasia (HED) is the most frequent form, also known as Christ-Siemens-Touraine syndrome (59)).Nail dystrophy, alopecia, or hypotrichosssis (sparse, shiny hair or eyelashes) ,lack of sweat glands and palmar-plantar hyperkeratosis are commonly seen abnormalities in patients with HED , wich is seen in 1 in 5000 to 1 in 10000 births (60)and is usually more severe in males due to its X-linked transmission, though autosomal dominant and recessive forms also exist.(61)

These patients, with typical features such as forehead and chin, flat nose and thick lips may face psychosocial problems due to their appearance figure21 .



Extraoral view of the patient **Radiographic view of the patient**

Figure21 : Patient with ED at 06 years(36)

ED is characterized by anodontia or oligodontia (cone-shaped teeth) **figure 22**, underdeveloped alveolar ridges , a decreased occlusal vertical dimension (OVD),reduced salivary secretion and dry oral mucosa ,making prosthetic rehabilitation difficult **(62)**

Figure22:Dental dysmorphologies with cone-shaped incisors and canines in patient with ED at age 8 years (32)

1.6. Implant :

1.6.1. Definition of implant:

A dental implant is a medical device surgically inserted into the maxillary or mandibular bone to replace a missing tooth root. Typically made of titanium or a biocompatible alloy, it serves as a support for a fixed or removable prosthesis that restores both function and aesthetics. The implant is based on the principle of osseointegration, which refers to the direct and stable integration into living bone. **(63)**

1.6.2. Classifications of implant:

1.6.2.1.*Depending on the placement within the tissues:*

According to a comprehensive overview of dental implant classifications, implants are categorized as follows:

A. Endosseous Implants (Intraosseous)

These implants are placed directly within the bone figure23, providing a stable foundation for prosthetic teeth. They are further subdivided into:

- **Root Form**: Screw-shaped implants resembling natural tooth roots
- **Blade Form**: Flat, plate-like implants used when bone width is limited.
- **Ramus Frame**: Used in the mandible, involving a frame that extends along the jaw(64)

Root form Blade form Ramus form

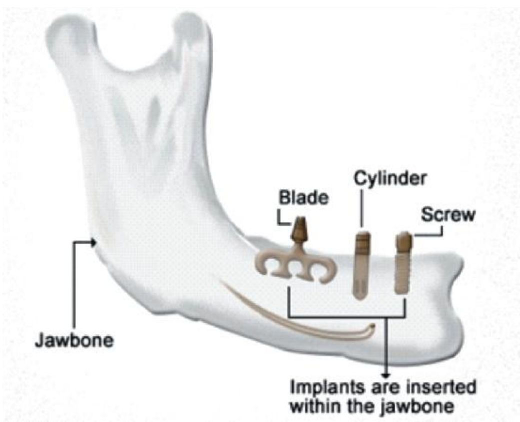


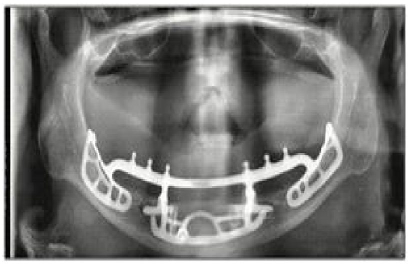
Figure23:Endosseous implants(15)

B. Subperiosteal Implants (Juxtaosseous)

These implants rest on top of the jawbone but beneath the gum tissue. They are suitable for patients with insufficient bone height. Subtypes include figure24:

- **Unilateral**: Implants placed on one side of the jaw.
- **Complete**: Covering the entire edentulous area.
- **Circumferential**: Encircling the jawbone (65)





Unilateral Complete Circumferential

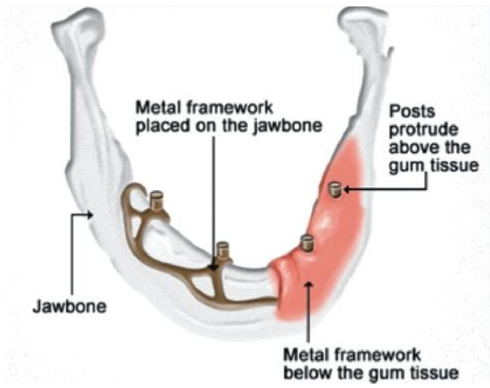
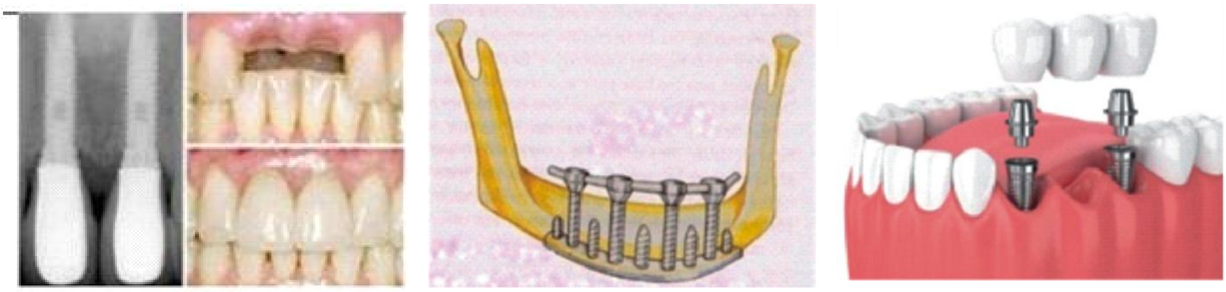


Figure24:Subperiosteal Implants (15)

C. Transosteal Implants

These implants penetrate through the entire thickness of the jawbone, from the buccal to the lingual side. They are less commonly used due to their invasive nature. Subtypes include figure 25:

- **Staple**: A staple-like implant passing through the mandible.
- **Single Pin**: A single pin inserted through the bone.
- **Multiple Pin**: Multiple pins used for anchorage (66)



Staple Single pin Multiple pin

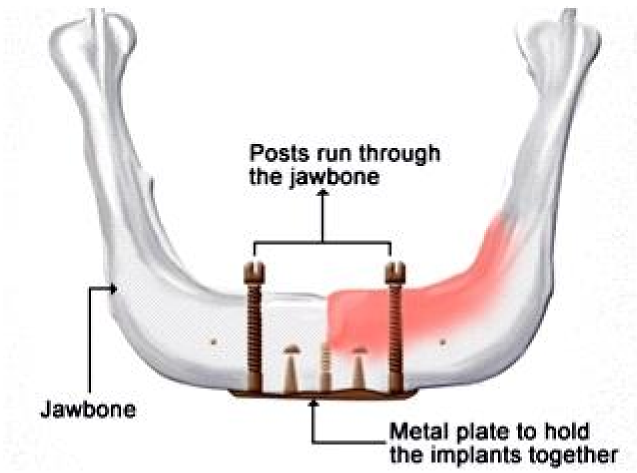


Figure25 : Transosteal implants (15)

1.6.2.2.*Depending on the materials used*

Based on the materials used, the implants can be classified into:

- Metallic implants: Titanium, Titanium alloy, Cobalt Chromium Molybdenum alloy.
- Non- metallic implants: Ceramics, Carbon etc. **(15)**

1.6.2.3.*Depending on their reaction with bone*

a) Bioinert Implants

Materials like titanium and zirconia do not chemically bond with bone, but promote mechanical integration (osseointegration) (67)

b) Bioactive Implants

These implants have bioactive coatings (e.g., hydroxyapatite, bioglass) that form a chemical bond with bone, accelerating healing and integration (10)

c) Biodegradable Implants (research phase)

Implants made from magnesium alloys or polymer composites that degrade over time after temporary support(68)

1.6.2.4.*Depending on the osseointegration:*

A. Osteointegrated implants:

Also called endosseous or bone-integrated implants, these implants form a direct structural and functional connection with the surrounding bone, without intervening soft tissue **(69)**

B. Non-Osteointegrated Implants:

These implants do not bond directly with bone and instead rely on mechanical retention or fibrous tissue encapsulation such as: mini-implants.

- **Mini implants:(MDIs)** are narrow-diameter implants figure26, typically less than 3.0 mm in diameter, designed for cases with limited alveolar bone or tight inter-dental spaces (70) .

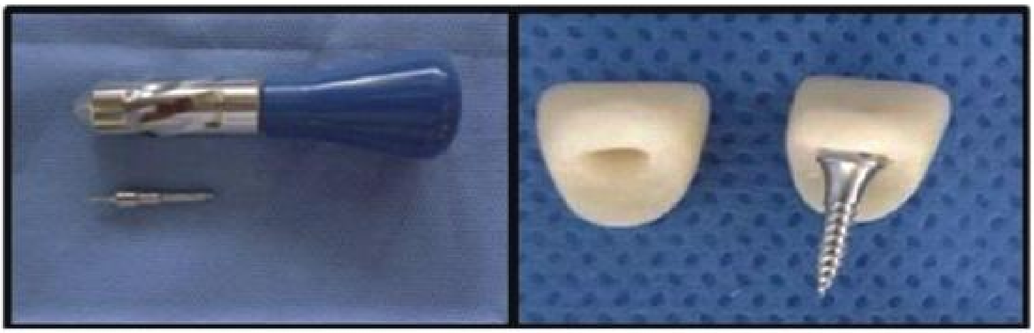


Figure26:Mini implants (71)

- Mini implant is composed of three main parts **figure27** :
  - **Threaded titanium body**: inserted directly into the alveolar bone.
  - **Neck or collar**: the transitional zone at the level of the gingiva.
  - **Ball head or O-ring attachment system**: provides direct connection with the overdenture or prosthetic device**(64)**

Figure 27: Parts of mini implants(72)

1.6.3. Component parts of dental implants :

Implant components can be divided into two types based on their type of function **figure28**

- **Main Components**: fixture -abutment and superstructure
- **Accessories**

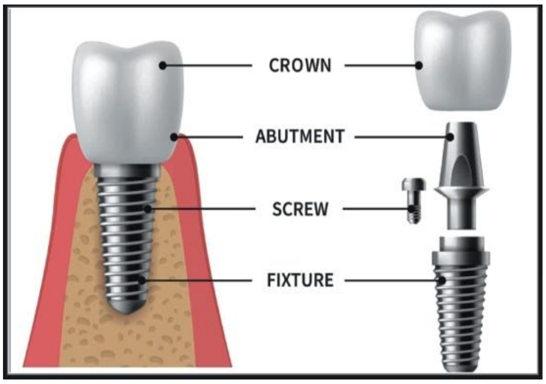


Figure28 :Main Components (15)

- **Main Components (73)**

- **Implant fixture:** the implant fixture is the component that is surgically placed into the bone. It is also called as 'implant body'. It could be threaded or non-threaded. The threaded implant is suitable for placement in dense cortical and fine trabecular bone.

It can be easily removed during surgery, if needed. Part of implant fixture are figure29:

- Body
- Crest Module
- Collar

Figue29: Part of Implant Fixture (15)

a) Body, b) Collar, c) Crest Module.

- **Implant abutment:** the abutment connects the implant fixture to the prosthetic tooth or crown. It is typically made of metal or ceramic and is screwed or cemented onto the implant fixture.
- **Implant superstructures:** a superstructure or crown is the prosthetic component that is fabricated with the support of dental implants. Implant superstructures can be a fixed prosthesis or removable prosthesis.

- **Accessories (Surgical):**

- **Cover screw :**

After surgical placement of implant, a screw is placed in superior aspect of two-piece implants to cover the connection for abutment during the healing period. It is also termed as healing screw figure 30

Figure 30: Cover screw of different implant system (15)

- **Gingival former :**

Gingival former component is required only for two stage implants. Following the second surgery to expose the implant, the cover screws body or abutment to a dental cast. The coping is are removed and gingival former are placed on attached to the implant fixture during impression the implant fixture. Also termed as healing abutment or per mucosal extension figure31 (73) .

Figure 31:Gingival Former (15)

- **Prosthetic:**

A. Implant analogue:

A replica of the entire dental implant, not intended for human implantation. Implant analogue is similar to implant fixture, but used in the model to fabricate the prosthesis in the laboratory. It is also termed as implant replica or lab analogue **figure 32 (73)**

Figure 32:Impression coping -analogue (15)

1)Implant analogue, 2) short, direct impression coping, 3) long retaining screw

B. Impression coping :

Impression coping is used with transfer impression to transfer the location of the implant surgery to expose the implant, the cover screws body or abutment to a dental cast. The coping is attached to the implant fixture during impression procedures using an impression screw.

Following impression making, the coping is removed from the implant fixture and attached to the implant analogue, to pour a cast. It is also termed as impression post, impression pin or transfer coping.

2. Implants in children:

2.1. History of implants in child:

The use of dental implants in child is not a new thing to talk about as pediatric implantology is decades old practice now .It was started more than 32 years ago when the National Institutes of Health held the Consensus Conference on dental Implants in a year 1988 where the acceptance of implant treatment came into consideration in U.S. dentistry (74)

Per-Ingvar Brånemarkis widely recognized as the pioneer of modern dental implantology. In the 1950s, he discovered that titanium implants could integrate with bone tissue, leading to the development of osseointegrated implants (75)

During the consensus development meeting in 1995 from the National institutes of Health in dental implant concluded that “children need special consideration given long term morbidity concerns, requirement of growth, manual dexterity, and coping skills. Hence, it is important to measure benefits of implant placement in growing patient against the concern regarding their premature placement

2.2. Indications and contraindications in children

2.2.1. Medical and dental conditions

A. Medical conditions:

Pediatric patients with ectodermal dysplasia (1988 National Institute of Health Consensus Development Conference on dental implants at Bethesda).

Implants combined with bone grafting in patients with cleft of the alveolus and palate.

B. Dental conditions:

Children and adolescents having oligodontia/anodontia as a second-line treatment option (according to the HAS).

Teeth lost due to trauma as a rare alternative.

Children and adolescents having agenesis and hypodontia after an orthodontic space management.

Uncooperative children who find it difficult to adjust to removable appliances.

Failure or intolerance of a conventional prosthesis.

2.2.2. Risks and contraindications

A. General considerations:

Medical: immunodeficiency, congenital cardiac problems, or metabolic illnesses might occasionally be linked to syndromic oligodontia and anodontia. Early implant therapy are contraindicated for certain diseases. Such treatments are also contraindicated in cases of psychiatric disease, radiotherapy in the implantation site, or aggressive malignancy treated with bisphosphonates.(64)

Psychological: the treatment should be delayed until a later age unless the child has attained a specific level of psychological maturity to accept it. The parents psychological readiness should also be taken into account(76)

Contraindication to general anesthesia: The first-line method for implantation in children is general anesthesia. As a result, the implant solution is contraindicated in any situation where general anesthesia is not appropriate (77)

B. Local considerations:

Presence of antomical structurs: Pre-implant planning using 3D imaging (CBCT)allows any neighbouring anatomical structures to be objectified (dental roots, emergence of the inferior alveolar nerve, mandibular canal etc.). If these structures are too close to the implant site, it may be inappropriate to place implants. In some cases ,pre-implant bone grafting surgery may remove the contraindication. (78)

Bone hypotrophy: this may be vertical or sagittal, Ideal implant conditions require a minimum of one millimetre of vestibular and palatal/lingual bone around the implant. In addition, the minimum distance between two symphyseal implants, in order to stabilize a complete prosthesis, must be at least one centimetre. Consideration should be given to the use of mini implants, whose reduced diameter would make it possible to overcome this anatomical difficulty.(64)

Residual growth zone: The placement of implants in the posterior mandibular and maxillary regions (beyond the canines) is contraindicated during the growth phase. Mandibular alveolar growth causes the implants to be buried, while maxillary resorption causes them to be exposed in the nasal cavities or sinuses. This phenomenon has been studied and described by G. Kearns team, who concluded that implants function similarly to ankylosed teeth since they do not coincide with alveolar growth.(79)

2.3. Type of pediatric prosthodontics

2.3.1. Single Implant-Supported prosthodontics:

- **Description:**

A single implant-supported prosthesis consists of a crown fixed on a dental implant placed into the alveolar bone, aiming to replicate the function and esthetics of a natural tooth **figure33**.

Figure33: Single Implant-Supported Prosthodontics (80)

- **Clinical use:**

Indicated in cases of isolated congenital agenesis (e.g., lateral incisors), dental trauma, or syndromic conditions like ectodermal dysplasia.

- **Advantages:**

- Preserves adjacent teeth — unlike conventional bridges, no tooth preparation is needed.
- Provides long-term esthetic and functional stability when placed after growth completion.
- Improves mastication, speech, and psychological well-being in pediatric patients with missing teeth **(81)**

2.3.2. Fixed implant supported prosthodontics (screw-retained bridge)

- **Description:**

This type of prosthesis is screwed or cemented onto multiple-osseous integrated implants, offering a stable and aesthetic long-term solution for complete or extended edentulism.

- **Clinical Use:**

Appropriate when sufficient bone anchorage is present and stable occlusion is desired.

- **Advantages:**
  - High functional stability
  - Excellent aesthetics
  - Patient comfort**(82)**

2.3.3. Implant-retained removable prosthodontics (overdenture)

- **Description:**

This type combines the benefits of conventional removable prostheses with implant-based retention using bars, locators, or ball attachments **figure34**

Figure34: Complete Removable Implant-Retained Prosthodontic Stabilized by a Bar System(83)

- **Clinical use:**

Commonly indicated for total or partial edentulism, especially in the maxilla or mandible, when additional retention and stability are required.

- **Advantages:**
  - Greater stability than traditional removable prostheses
  - Easier hygiene access
  - Less invasive than full fixed restorations **(84)**

2.3.4. Prosthodontics supported by mini implants(narrow-diameter implants)

- **Description**:

Mini-implants are used to support temporary or permanent prostheses, particularly when bone volume is limited **figure35** .

Figure35:Prosthodontic supported by mini implants (80)

- **Clinical use:**

Suitable for cases where bone augmentation is not feasible or desired. Also used for immediate stabilization.

- **Advantages:**

  - Minimally invasive placement
  - Effective in reduced bone volume
  - Serves as a transitional or semi-definitive solution**(85)**

2.4. Specifics features of implantology in children

2.4.1. Periodontal Features

Peri-implant soft tissues in children are generally underdeveloped, with reduced marginal keratinization and thinner mucosa compared to adults. This immaturity increases susceptibility to infection and complicates hygiene maintenance **(79).**

Children present a higher risk of peri-implant inflammation, especially when oral hygiene is poor or keratinized mucosa is lacking, which may compromise long-term implant success **(86)**.When the keratinized band is insufficient, soft tissue grafting may be necessary to reinforce the peri-implant mucosa and prevent complication

2.4.2. Surgical Features

Implant placement in growing patients is complicated by the risk of infra occlusion due to continued vertical bone growth. This necessitates careful surgical timing (17) .Growth cessation must be confirmed—often by serial cephalometric superimposition—before implant placement**(86)**

Careful planning is required to avoid developing tooth germs, maxillary sinuses, and the inferior alveolar nerve; cone beam computed tomography (CBCT) is essential for accurate three-dimensional assessment .(79)
Bone quality in children is often low , making primary implant stability challenging and requiring adapted surgical techniques **(87)**
In syndromic or congenital agenesis cases, such as ectodermal dysplasia, bone grafting is frequently necessary prior to implant insertion .(88)

2.4.3. Prosthetic Features

Prosthetic designs in children must be temporary, adjustable, and compatible with craniofacial growth. Screw-retained restorations are favored for their ease of removal and modification (89)

Implant-retained overdentures are particularly suited to cases of anodontia, offering stability while allowing easy adaptation during growth.(90)
Restorations should be lightweight, easy to clean, and must not interfere with the eruption of adjacent permanent teeth (91)
Implants and prostheses should be integrated into a multidisciplinary orthodontic treatment plan to preserve space, guide development, and achieve long-term functional and esthetic outcomes **(82)**

2.4.4. Complications

Oral implantology in children involves several specific complications, mainly due to ongoing craniofacial growth and immature peri-implant tissues. One of the most common issues is **infra-occlusion**, where the implant remains fixed in the bone while adjacent natural teeth continue to erupt, resulting in esthetic and functional discrepancies—particularly in the anterior maxilla **(86)**

Placing implants too early can also disrupt alveolar and facial bone development, especially in syndromic patients, potentially leading to asymmetries, bone resorption, or impaired vertical growth **(92)**

Children are also more prone to **peri-implant diseases** such as mucositis and peri-implantitis due to reduced soft tissue keratinization and challenges in maintaining optimal oral hygiene. If not addressed, these conditions can cause bone loss and implant failure **(93)** Furthermore, achieving primary stability is more difficult in pediatric patients due to lower bone density , increasing the risk of micro movements or early implant loss (**(94)**
Surgical placement also carries a higher risk of complications, such as injury to developing tooth germs, adjacent roots, maxillary sinuses, or the inferior alveolar nerve, which necessitates precise preoperative planning using advanced 3D imaging such as CBCT **(95)**
Prosthetic complications may include screw loosening, component fractures, and prosthetic misfit due to continued jaw growth, requiring ongoing adjustments (22)

Lastly, these complications may have significant psychosocial effects, particularly when esthetics are compromised in the visible anterior region, potentially affecting the child's self-esteem and social Thus, implant treatment in children demands cautious, multidisciplinary planning and long-term follow-up**.**

3. Clinical cases series

3.1. Case 01: Management of oligodontia in a patient with hypohidrotic ectodermal dysplasia

This 2005 clinical case illustrates the various stages of implant placement in a child diagnosed with a syndromic form of oligodontia, specifically Hypohidrotic Ectodermal Dysplasia (HED). **(80)**

3.1.1. Case description

The patient, a young Caucasian boy, was three years old when the diagnosis of HED was established.

A. Extra-oral examination

His skin was described as dry, pale, and hypo pigmented. His hair was blond, fine, and sparse, and the same applied to his eyelashes and eyebrows **figure 36(A)**

Figure 36: Frontal view (A) and panoramic radiograph (B) of the patient.

B. Intra-oral examination

It revealed severe oligodontia affecting both dental arches. In the permanent dentition (at the time of clinical examination and panoramic radiograph), only the maxillary central incisors and the mandibular first molar were present. The diagnosis of oligodontia was confirmed by the panoramic radiograph figure 36(B).

The examination also revealed severe alveolar atrophy in both the maxilla and mandible

C. Initial treatment

At the age of five, two removable partial dentures were fabricated. Due to ongoing craniofacial growth and progressive alveolar atrophy, the mandibular prosthesis became increasingly unstable. The resulting functional impairment, combined with the psycho-social difficulties experienced by the patient, led the clinical team to consider implant-supported rehabilitation by the age of eight.

The proposed treatment involved the placement of two symphyseal implants in the mandible to stabilize a complete removable prosthesis.

3.1.2. Secondary implant therapy

A. Pre-surgical phase

Implant planning was performed using study models mounted on an articulator. A prospective tooth setup allowed for the determination of the ideal positioning for the two symphyseal implants. An individualized surgical stent (the equivalent of a modern surgical guide) was fabricated to ensure precise implant placement during the surgical procedure.

The implants selected were Nobel Biocare MK III implants, 3.75 mm in diameter and 13 mm in length, with a cylindrical design.

B. Surgical phase

Surgery was carried out under regional local anesthesia following the elevation of a full-thickness mucoperiosteal flap figure 37(A)

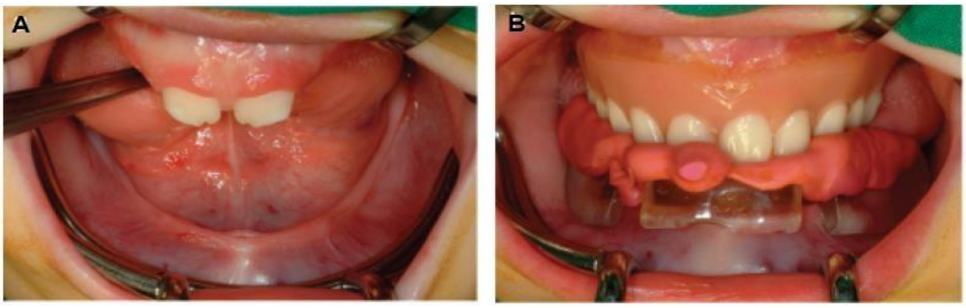


Figure37: Initial surgical situation (A). Placement of the surgical splint and maxillary setup (B)

The maxillary setup and the surgical stent were positioned in place **figure37 (B)**

The drilling site was initially marked using a round bur **figure 38 (B)**

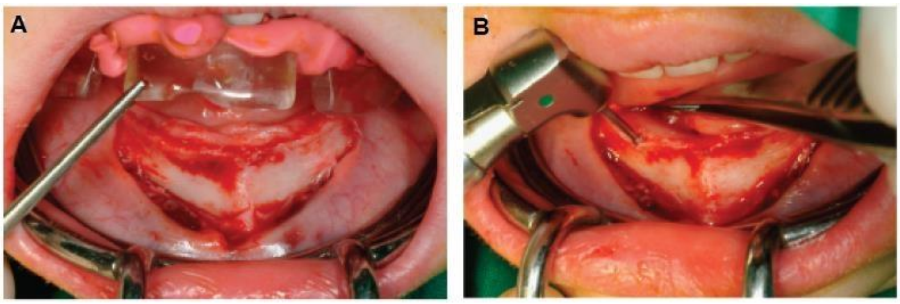


Figure 38 : Elevation of a full-thickness flap (A), Marking of the drilling site with a round bur (B)

The two implant osteotomies were performed using the full drilling sequence, during which the angulation was verified using direction indicators **figure 39 (A)**.

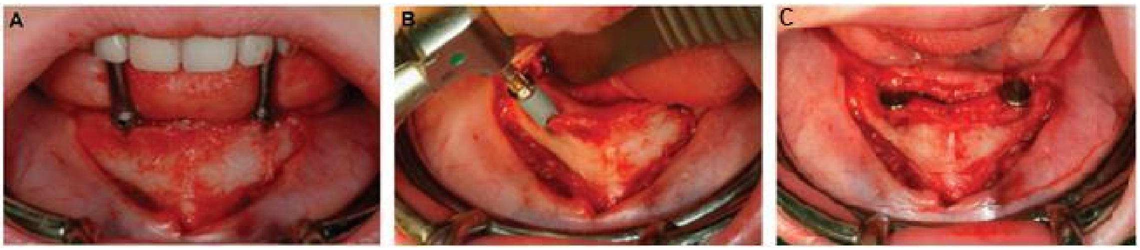


Figure 39:Verification of the implant axis (A), placement of the implants (B), placement of the healing abutments (C)

The implants were inserted with torque values in accordance with the manufacturer's specifications and healing abutments were subsequently placed over the implants **figure 39 (B, C) .**

C. Healing phase

A healing period of three months was observed prior to the functional loading of the implants **figure 40**. Following this, an additional two-week period was respected before proceeding with the fabrication of the implant-supported prosthesis.

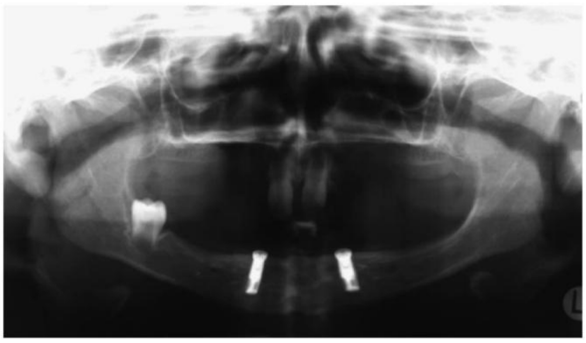


Figure40: Panoramic control radiograph during the healing phase

D. Prosthetic phase

In the maxilla, the treatment plan involved preserving the two maxillary central incisors and covering them with a complete removable denture to ensure uniform esthetics and occlusal plane alignment. The prosthesis was designed to replicate the temporary dentition, consisting of a total of ten teeth **figure41 (E,F).**

In the mandible, a bar-retained attachment system was selected. Due to the mechanical constraints associated with the bar, the mandibular prosthesis was fabricated using a cobalt-chromium framework covered with resin. The mandibular prosthesis also included ten teeth **figure 41 (A, D)**

Figure 41 : Implant-retained mandibular complete removable denture (A, B, C, D) and maxillary complete removable

E. Prosthesis placement

Prosthesis delivery was accompanied by occlusal equilibration, provision of oral hygiene instructions, and scheduling of follow-up appointments. The following photographs illustrate the extraoral **figure 42(A)** and intraoral outcomes of the rehabilitation **figure 42(B)**.

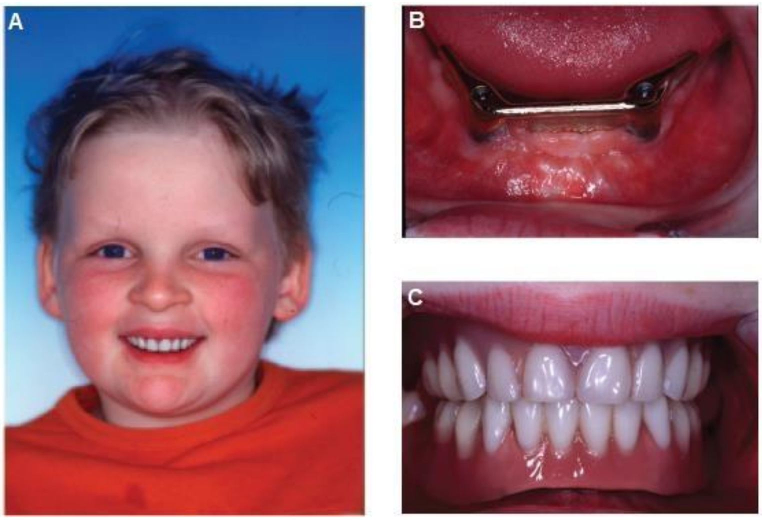


Figure42 : Extra-oral view (A) and intra-oral views (B and C) of the implant-supported rehabilitation

3.1.3. Outcome and follow-up :

The young patient adapted well to his new implant-supported prosthesis. His parents reported significant improvements in his self-confidence, social interactions, and food intake. The new prosthesis notably enabled him to eat foods he had previously avoided, such as apples and meat.

At the time of writing, the implants and prosthesis had been in function for two years without any reported complications.

3.2. Case 02: Prosthetic rehabilitation of four permanent maxillary incisors following traumatic injury

This clinical case describes the various stages of management and the consequences of a maxillo-facial trauma sustained by a 10-year-old boy **(96)**

3.2.1. Case description

In August 2015, a 10-year-old patient was admitted to the maxillo-facial surgery department at Clermont-Ferrand University Hospital following a dental trauma, the details of which were not specified.

The medical history revealed good general health, no allergies, and no exposure to passive smoking.

The patient exhibited an Angle Class II malocclusion, attributed to a skeletal Class II pattern according to Ballard's classification.
Clinical and radiographic examinations revealed extrusion of teeth 11 and 21, intrusion of teeth 12 and 22, as well as an associated alveolar fracture.

3.2.2. Chronology of pre-surgical management

August 2015 (Maxillo-facial surgery): The trauma occurred with the aforementioned injuries. Management was performed under general anesthesia in the maxillo-facial surgery unit, including reduction of the alveolar fracture, repositioning of the extruded teeth, and placement of a Dautrey arch.

October 2015 (Orthodontics): Orthodontic consultation revealed severe mobility and root resorption of the two central incisors, likely due to the absence of timely endodontic treatment following the trauma.

It was decided to remove the Dautrey arch and to initiate fixed multi-bracket orthodontic treatment **figure 43**

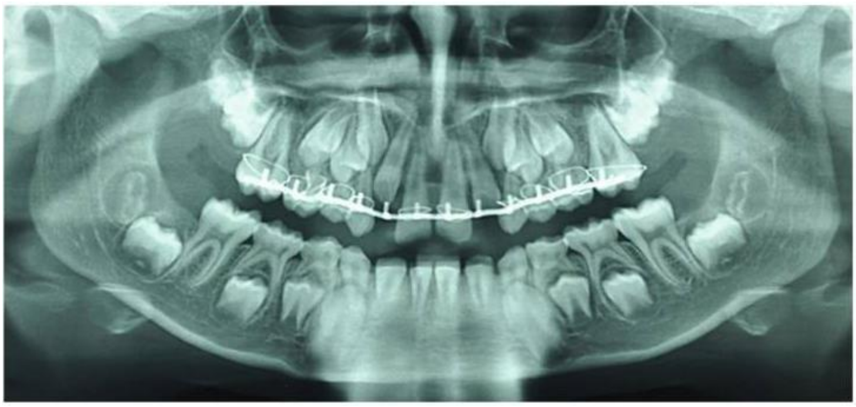


Figure 43: Panoramic radiograph from October 2015, prior to the removal of the Dautrey arch. Munoz-Sanchez et al., 2021

December 2015 (Endodontics): Root canal treatment of teeth 11 and 21 was performed over multiple sessions, including apical closure with calcium hydroxide and canal obturation with gutta-percha.

April 2018 (General dentist): Pink spots and cervical resorptions appeared on both lateral incisors. The cold sensitivity test was negative on these two teeth.

May 2018 (Endodontics and Conservative Dentistry): Granulation tissue curettage, endodontic treatments and obturation of cervical resorptions on teeth 12 and 22 were performed.

May 2019 (Surgery and Orthodontics): Due to near-total root resorption, the decision was made to extract teeth 11 and 21. Two orthodontic brackets (for teeth 11 and 21) were placed on the orthodontic arch to maintain the space **figure 44 (A, B, C)** . Two new infectious episodes occurred during the summer on tooth 12.

Figure 44 : Periapical radiograph showing root resorptions of teeth 11 and 21 (A and B), prior to their extraction and replacement with veneers bonded to the orthodontic arch (C). Munoz-Sanchez et al., 2021

January 2020 (surgical procedure): decision to extract tooth 12 due to recurrent infections.

3.2.3. Surgical phase following failure of conservative dentistry

In February 2020, after the extraction of tooth number 12, clinical and radiographic examinations revealed a significant alveolar defect in the vestibular region. Additionally, the cephalometric analysis performed in 2019 showed that the patient was at their pubertal growth peak at that time. These factors contraindicated the placement of traditional implants.

A. Therapeutic options:

Two solutions were then considered: the placement of mini-implants or the fabrication of a removable partial denture. The patient declined a removable solution. Moreover, the bone volume needed to be preserved for the placement of traditional implants once growth was completed.

Therefore, in agreement with the patient, their parents and the multidisciplinary team, the decision was made to place four OBI mini-implants (Euroteknika) simultaneously with the extraction of tooth 22. The four implants chosen had a diameter of 2.7 mm and lengths ranging between 9 and 15 mm. This implant model was selected, among other reasons, for its simple protocol requiring the use of only a single drill.

B. Pre-surgical planning:

An optical impression and a CBCT scan were performed. Implant planning was carried out using 3Shape Implant Studio Software **figure45 .**

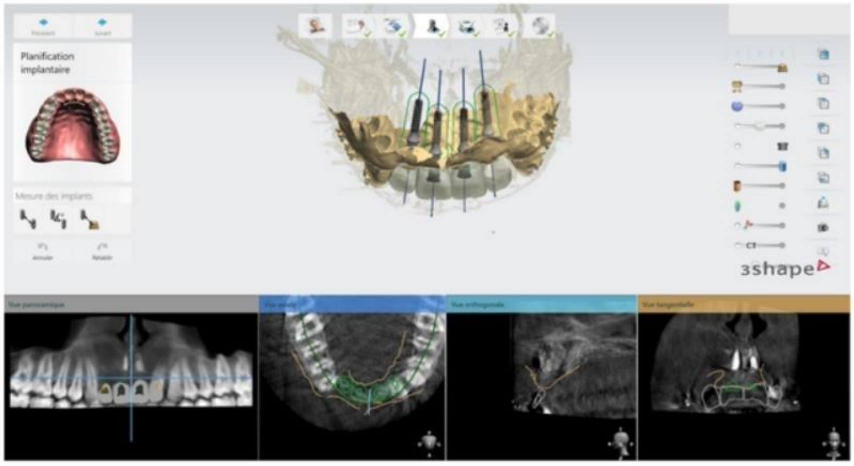


Figure45 :Screenshot of the 3Shape Implant Studio Software during the implant planning phase. Munoz-Sanchez et al., 2021

This software allows the optimal positioning of implants based on the amount of alveolar bone and the desired position of the prosthetic restoration. Following the planning phase, the surgical guide is designed **figure 46(A)** and then printed **figure 46(B).**

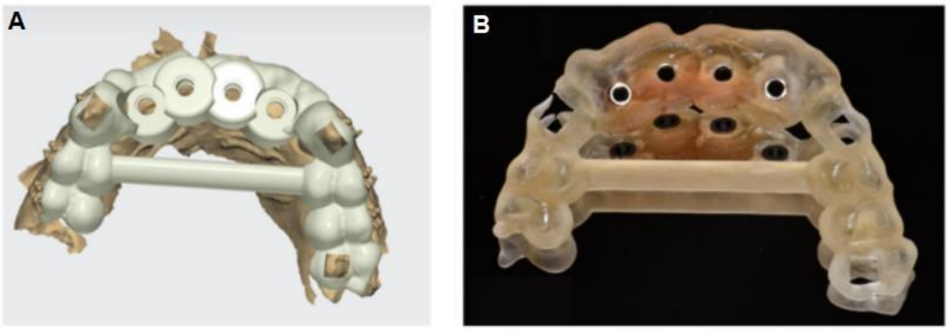


Figure46 :Digital model (A) and printed model (B) of the implant surgical guide. Munoz-Sanchez et al., 2021.

It should be noted that the gutta-percha (endodontic filling material used on teeth 11 and 21) remains present in the bone **figure 44(C)**. After confirming that the surrounding bone tissue was free of infection, the material was intentionally left in the alveolar bone to prevent any resorption following its curettage. The filling material does not interfere with the placement of the mini-implants, which will be positioned more palatal. Its removal is planned during the bone graft procedure in adulthood, after the removal of the temporary mini-implants.

C. Surgical phase

The surgery was performed under general anesthesia. It began with the extraction of the remaining tooth 22 and curettage of the alveolus **figure 47(A)**. The surgical guide is tried in **figure 47(B)**then removed for the passage of a pilot drill **figure 47(C)**.

Figure 47 : Surgical phase: extraction and curettage of tooth 22 (A), trial fitting of the guide (B), pilot drill insertion (C). Munoz-Sanchez et al., 2021

The drilling is performed using the surgical guide **figure 48(A)**, the implant axis is verified with a gauge **figure 48(B)**and the implant is manually torque-tightened **figure 48(C)**.

Figure 48 : Surgical phase: drilling using the guide (A), axis verification with a gauge (B), manual placement of the implant (C). Munoz-Sanchez et al., 2021

D. Prosthetic phase

➢ **Transitional phase**

A transitional prosthesis, consisting of four resin veneers mounted on an orthodontic arch-wire, is placed during the three-month osseointegration period **figure 49**.

Figure49: Orthodontic archwire supporting the transitional prosthesis. Munoz-Sanchez et al., 2021

➢ **Functional phase**

Once the osseointegration period was completed, an impression was taken using silicone material. The four-unit bridge, fabricated by the laboratory, was tried in and then cemented with a glass ionomer cement (GIC). A first follow-up was conducted two months after prosthesis insertion. A second follow-up was carried out after removal of the multi-bracket appliance, i.e., six months after the bridge placement **figures 50and 51**.

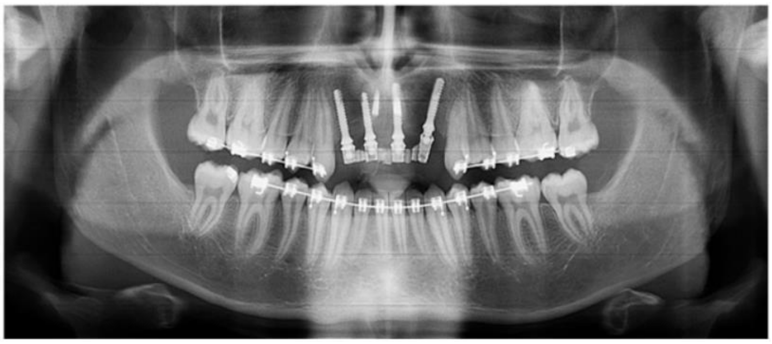


Figure50 : Panoramic radiograph taken at the second follow-up (6 months after bridge placement), prior to the removal of the multi-bracket appliance. Munoz-Sanchez et al., 2021

Figure51:Intra-oral view six months after prosthesis insertion and after removal of the multi-bracket appliance. Munoz-Sanchez et al., 2021

3.2.4. Conclusion:

This case illustrates the therapeutic pathway that led the multidisciplinary team to consider an implant-based solution (following trauma) in a patient who had not yet completed skeletal growth. Initial curative, then palliative endodontic treatments made it possible to preserve the alveolar bone to the greatest extent possible. These conservative approaches also helped delay the surgical intervention until the descending phase of the pubertal growth peak. The aim of this therapeutic strategy was to stabilize bone volume while providing the patient with a comfortable and esthetic interim solution. These four mini-implants will eventually be removed in adulthood and replaced with two conventional implants.

II. *MATERIAL AND METHOD:*

1. Type of study:

This is a systematic literature review of articles published from 2000 to 2025 on the placement of implants in pediatric patients.

2. Principal objectives:

Evaluate the clinical feasibility of dental implants in growing children.

3. Secondary objectives:

Define the epidemiological characteristics of candidates for implant treatment

Establish the correlation between maxillary growth and the feasibility of oral implantology in kids.

Establish recommendations for pediatric oral implantology.

4. Study population:

Our review includes articles that meet the inclusion criteria

a. Inclusion criteria:

- Year of publication: 2000 to 2025.
- Article language: French or English.
- Document type: review, systematic review, clinical case reports and series.

b. Criteria for non-inclusion:

- Articles published prior to 2000.
- Articles published in other languages (Spanish).

5. *Sources of data:*

The literature search was performed using three electronic databases: **PubMed, ScienceDirect**and **ProQuest**

6. *Search strategies:*

The terms used for literature research were related to the interest of oral implantology in pediatric patients.

This research was started in September 2024

We used in the search strategy the following MeSh terms:

- **Pubmed:** dental implants, child
- **Science Direct**: pediatric, dental implants.
- **ProQuest :** pediatric , dental implants.

7. *Data extraction sheet:*

Articles that met the inclusion criteria were then selected, categorized, and analyzed using a standardized data extraction sheet.

The following data were collected from each study:

- The title of article
- Author(s)
- Year of publication
- Patient number
- Etiology
- Age of patients
- Evaluation of growth
- Sector of implantology
- Implant details

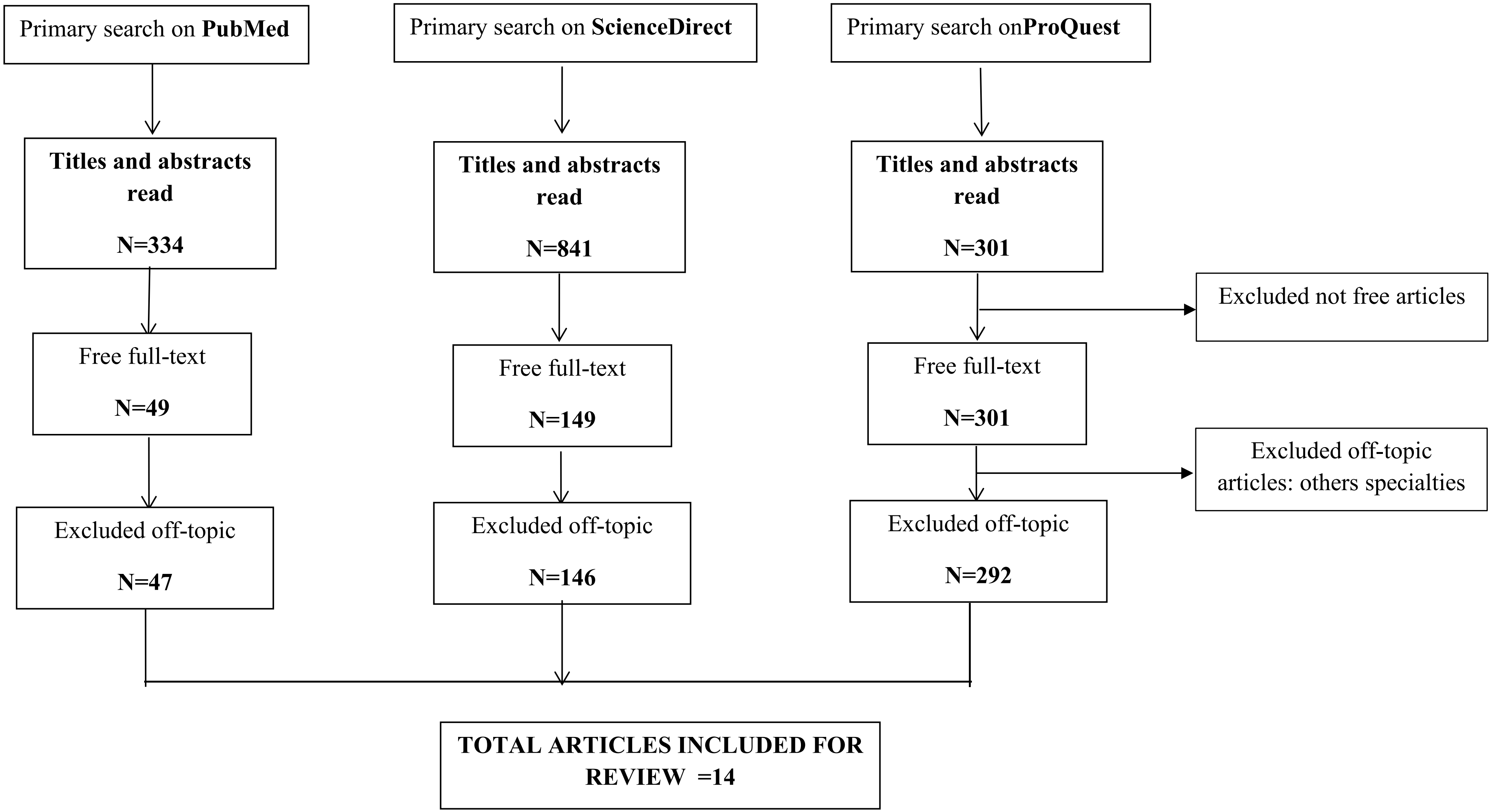
- Type of dental prosthesis designed
- Follow-up details (control)
- Rate of success

8. Results of the different phases of articles search:

The literature search was conducted over several months independently using the **PubMed**, **ScienceDirect** and **ProQuest** databases.

Initially, **1476 articles** were identified. Following the application of predefined inclusion criteria, **499 articles** were selected for further evaluation. After independent manual screening, **485 articles** were excluded due to a lot of reasons such as: off-topic, patients are not under 18 years old. Ultimately, **14 articles** met all inclusion criteria and were included in the final analysis.

The details of the included and excluded articles are represented in the following **Flow-chart.**



Flow-Chart showing the search terms and screening of systematic reviews in various databases

Tableau I: depicting the **PICO information** of included articles.

Population	**Intervention**	**Comparison**	**Outcome**
Children under the age of 18 years	Single tooth or multiple dental implants	Etiology: caries-trauma-ectodermal dysplasia Age of patients Sector of implantation Type of dental prosthesis	Success (Feasibility and viability)

III. *RESULTS:*

Tableau II: *detailing the articles.*

Article title	Author	Year of publication	Population pf article /patients number	Objective
1. Pediatric dental implant (India)	Prachi Gholap	2022	Youngster at age of 02 years (treatment started at age of 11 years)	To clarify if dental implants might be used in pediatric patients.
2. Use of dental implants in children (Brazil)	Cello Percinoto	2001	36 patients	To discuss the viability of implant use in growing patients and the influence of maxillary and mandibular skeletal and dental growth on the stability of those implants.
3. Adverse effects of implants in children and adolescents (India)	Rekhalakshmi Kamatham	2019	08 articles 11 adolescents (7boys and 4 girls)	To determine the evidence on the adverse effects of placing dental implants in healthy growing children

4. Six-Year survival of a mini dental implant-Retained overdenture in a child with ED **(Turkey)**	Serdar Kilic	2015	A 06 year old boy	To evaluate the 6year survival of mini-implant-retained mandibular overdenture in a patient with ED.
5. Rehabilitation of ectodermal dysplasia patients presenting with hypodontia: outcomes of implant rehabilitation part 1 **(Australia)**	Mariela Machado	July 2018	6 patients (4 patients under <18years) :3boys and 2 girls	To evaluate the pre and post perceptions of patients with ED who have been referred to Westmead Centre for Oral Health for treatment with dental implants
6. Dental implants in growing patients: A quality assessment of systematic reviews **(India)**	Joe Mathew Cherian	August2023	04 systematic reviews	To evaluate evidence-based literature on single or multiple dental implant placements in children (up to 17 years), identify areas lacking and gaps in knowledge and evaluate the quality of said research around pediatric dental implants.
7. Commentary on mini dental implant insertions in children with ED **(Italy)**	Funda Göker	March 2024	28 articles	To discuss the challenges of implant placement in children and seek to identify potential complications and the most appropriate rehabilitation protocols.

8. Implant-supportedoral rehabilitation in child with ED (Brazil)	Thaisa Cezaria Triche-	July 2016	A female patient	To describe oral rehabilitation comprising complete implant-supported dentures for the mandible and a regular denture for the maxilla in a girl with hypodontia due to ED
9. Implant Failure in Young children with ED: A retrospective evaluation of use and outcome of dental implant treatment in children (Sweden)	Birgitta bergendal	2008	26 children below age 16(18 girls and 08 boys)	To survey dental implant treatment in children up to age 16 years with special reference to young children with ectodermal dysplasia (ED) and anodontia in the lower jaw
10. Dental implant therapy for a child with X-linked hypohidrotic Ed (Sweden)	Birgitta Bergendal	2015	One boy	To report on oral rehabilitation of where treatment involved dental implants and oral care management by a multidisciplinary team of specialist
11. Hypohidrotic ectodermal dysplasia: dental clinical, genetic	B.Kargul	2001	03 patients (01 girl et 02 boys)	To present and analyze the dental, clinical, genetic, and dermatoglyphic characteristics of three pediatric

and dermatoglyphic findings of three cases (Turkey)				cases diagnosed with hypohidrotic ectodermal dysplasia (HED). The study also describes the diagnostic approach and highlights the multidisciplinary treatment strategies
12. Dental implants in children: a multidisciplinary perspective for long-term success review (India)	Nidhi Agarwal	2017	363 patients	To understand the implications of growth and growth assessment and recommendations for the formulation of the treatment plan in pediatric dental implant patients.
13. Pre-implant surgery comlexity for achieving implant – supported prosthetic rehabilation in oligodontia patients (France)	Ludovic Lauwers	2024	119 patients (4 patients under <18 years old)	Evaluate the ability to predict pre-implant surgery complexity based on age, number of missing teeth, and number of implants required to achieve implant-supported prosthetic rehabilitation
14. Mini implants: Alternative for oral rehabilitation of a child with ED (Brazil)	Bianca Zeponi Fernandes Mello	2015	One girl	To test the mini-implants as an alternative for oral rehabilitation of children with ectodermal dysplasia.

***Tableau III:**According to the etiology*

Article title	Patients number	Etiology	Conclusion
1. Pediatric dental implant **(India)**	Youngster at age of 11 years	**Congenital anodontia**	Multidisciplinary approach is necessary Good esthetic and functional results of osteointegrated implant Mandibular implant-supported overdenture was well tolerated after 03 years of folllow up
2. Use of dental implants in children **(Brazil)**	36 patients	**Trauma** **Ectodermal dysplasia**	Positive soft and osseous tissue reaction to the implants Most of the failures happened due to subsequent traumatic injuries sustained during the healing phase after implant placement Infra-occlusion was reported as a complication Follow up :5 years
3. Adverse effects of implants in children and adolescents **(India)**	-11 adolescents (7boys and 4 girls)	**Caries** **Trauma** **Agenesies**	No report about a failure in the form of pain/paresthesia , mobility or peri-implant radiolucency Good osseointegration was observed

			06 cases of infra-occlusion Follow up :4-5 months to 13 years
4. Six-Year survival of a mini dental implant-Retained overdenture in a child with ED **(Turkey)**	A 06 year old boy	**Ectodermal dysplasia**	During the 6 year of follow up period ,no evidence observed of intensive resorption in the peri-implant bone No functional and esthetic problems
5. Rehabilitation of ectodermal dysplasia patients presenting with hypodontia: outcomes of implant rehabilitation part 1 **(Australia)**	6 patients(4 patients under <18years) :3boys and 2 girls	**Ectodermal dysplasia**	Good scores of visual analogue scale of :aesthetics ,chewing, diet restriction and speech after treatment Encouraging outcomes Follow up : 1- 7 years
6. Dental implants in growing patients: A quality assessment of systematic reviews **(India)**	Children under 17years	**Trauma** **Agenesies**	Complication of infra-occlusion
7. Commentary on mini dental implant insertions in children with ED **(Italy)**	-28 articles	**Ectodermal dysplasia**	Mini implants improve the stability which has positive impact on oral function. Follow up :1-20years

8. Implant-supportedoral rehabilitation in child with ED **(Brazil)**	-A female patient	**Ectodermal dysplasia**	Restoration of masticatory ,phonetic and esthetic function Enhancing the patient's self-esteem and overall social well-being Follow up : 04 years
9. Implant Failure in Young children with ED: A retrospective evaluation of use and outcome of dental implant treatment in children **(Sweden)**	-26 children (18 girls and 08 boys)	**Nanosyndromic tooth agenesies n=14** **Trauma n=7** **Ectodermal dysplasia and anodontia n=5**	Complication of lost implants was reported High implants survival rate after 05 years of follow up
10. Dental implant therapy for a child with X-linked hypohidrotic Ed **(Sweden)**	A boy	**Ectodermal dysplasia**	Osteointegrated implants after over 25 years of follow up Satisfaction of patient with his denture was reported
11. Hypohidrotic ectodermal dysplasia: dental clinical, genetic and dermatoglyphic findings of three cases **(Turkey)**	03 patients (01 girl et 02 boys)	**Ectodermal dysplasia**	Osteointagrated implants were showed Rehabilitation of the oral conditions of the children

12. Dental implants in children : a multidisciplinary perspective for long-term success review **(India)**	256patients	**Congenital anodontia** **Ectodermal dysplasia**	Multidisciplinary approach is necessary Improving masticatory and esthetic The alveolar bone assessment is carried out through coputed tomography (CT) or cone beam Osteointegrated implant and no implant failures were reported Follow up :03 years
13. Pre-implant surgery comlexity for achieving implant –supported prosthetic rehabilation in oligodontia patients **(France)**	119 patients (4 patients under <18 years)	**Oligodontia**	Good osteointegrated implants were showed after 03 years
14. Mini implants: Alternative for oral rehabilitation of a child with ED **(Brazil)**	A girl with hypodontia	**Ectodermal dysplasia**	Good adaptation of dental prosthesis and satisfaction with treatment . Follow up :06 months

The etiology of edentulism plays a pivotal role in implant success in children, with trauma cases showing the highest success rates and ectodermal dysplasia presenting the most challenges. Early diagnosis, growth-aware planning, and individualized care are key to optimizing outcomes across different etiologies

Tableau IV: According to the age.

Article title	Age	Conclusion
1. Pediatric dental implant **(India)**	**Youngster at age of 02 years** **Treatment started at age of 11 years**	The multidisciplinary pre-implant assessment began at the age of 2 years . Good esthetic and functional results following implantation at 11 years old. Mandibular implant-supported overdenture was well tolerated after 03 years of folllow up
2. Use of dental implants in children **(Brazil)**	**3 and 9 to 18 years**	Positive soft and osseous tissue reaction to the implants Most of the failures happened due to subsequent traumatic injuries sustained during the healing phase after implant placement Infra-occlusion was reported as a complication Follow up :5 years

3. Adverse effects of implants in children and adolescents (India)	**<19ans** **-Age of placement implant 10-17years(mean age =13,4 years)**	No report about a failure in the form of pain/paresthesia , mobility or peri-implant radiolucency Good osseointegration was observed 06 cases of infra-occlusion
4. Six-Year survival of a mini dental implant-Retained overdenture in a child with ED (Turkey)	**06 years**	During the 6 year of follow up period ,no evidence observed of intensive resorption in the peri-implant bone No functional and esthetic problems
5. Rehabilitation of ectodermal dysplasia patients presenting with hypodontia: outcomes of implant rehabilitation part 1 (Australia)	**12-18 ans**	Good scores of visual analogue scale of :aesthetics ,chewing, diet restriction and speech after treatment Encouraging outcomes Follow up : 1- 7 years
6. Dental implants in growing patients: A quality assessment of systematic reviews (India)	**<17years**	Complication of infra-occlusion
7. Commentary on mini dental implant insertions in children with ED (Italy)	**3-18years**	Mini implants improve the stability which has positive impact on oral function. Follow up :1-20years

8. **Implant-supportedoral rehabilitation in child with ED** **(Brazil)**	**8 years old**	Restoration of masticatory ,phonetic and esthetic function Enhancing the patient's self-esteem and overall social well-being Follow up : 04 years
9. Implant Failure in Young children with ED: A retrospective evaluation of use and outcome of dental implant treatment in children **(Sweden)**	**<16years**	Complication of lost implants was repported High implants survival rate after 05 years of follow up
10. Dental implant therapy for a child with X-linked hypohidrotic Ed **(Sweden)**	**At 3 years (received implant at 7years)**	Osteointegrated implants after over 25 years of follow up Satisfaction of patient with his denture was reported
11. Hypohidrotic ectodermal dysplasia: dental clinical, genetic and dermatoglyphic findings of three cases **(Turkey)**	**Four year old male who received implants**	Osteointagrated implants were showed Rehabilitation of the oral conditions of the children

12. Dental implants in children : a multidisciplinary perspective for long-term success review **(India)**	**9- 18 years**	Multidisciplinary approach is necessary Improving masticatory and esthetic The alveolar bone assessment is carried out through coputed tomography (CT) or cone beam Osteointegrated implant and no implant failures were reported Follow up :03 years
13. Pre-implant surgery comlexity for achieving implant –supported prosthetic rehabilation in oligodontia patients **(France)**	**14-17 years**	No evidence of peri-implant bone loss or tissue destruction was observed during the clinical and radiograohic follow up
14. Mini implants: Alternative for oral rehabilitation of a child with ED (Brazil)	**9 years old**	Good adaptation of dental prosthesis and satisfaction with treatment . Follow up :06 months

The majority of articles recommend placing dental implants in children after skeletal growth is nearly complete—typically around 15 years in girls and 17 in boys This timing reduces complications like infra-occlusion and implant malposition. While early placement is possible in select cases (e.g., ectodermal dysplasia), has been successfully reported as early as 5 years of age.

Tableau V: According to the evaluation of growth:

Article title	Patients number	Evaluation of growth	Conclusion
1. Adverse effects of implants in children and adolescents(India)	-11 adolescents (7boys and 4 girls)	**Hand wrist radiographs methode)** **Cephalometric analysis**	Evaluate the skeletal maturation to minimize infra-occlusion
2. Six-Year survival of a mini dental implant-Retained overdenture in a child with ED(Turkey)	A boy	**Cephalometric evaluation before peak jaw growth**	Allow seamless normal growth pattern of unerupted maxillary second molars and the eruption of these molars was thus completed uneventfully
3. Dental implant therapy for a child with X-linked hypohidrotic Ed(Sweden)	**Patient at 3 years (received implant at 7years)**	**Cephalometric evaluation** **ANB= -1**	No evident increased height of the corpus of the mandible 2 conclusion (succes)

The authors placed implants in children outside the peak pubertal growth phases which typically occur between 10–15 years in girls and 12–17 years in boys—to avoid complications and ensure better implant stability. Their cases emphasize that systematic growth evaluation is essential for successful treatment planning and long-term outcomes.

Tableau VI: According to the sector of implantation:

Article title	Patients number	Sector of implantation	Conclusion
1. Pediatric dental implant(India)	Youngster at age of 02 years	**Mandibular anterior region**	Good esthetic and functional results Multidisciplinary approach
2. Use of dental implants in children(Brazil)	35 patients	**Mandibular anterior region**	Positive soft and osseous tissue reaction to the implants Most of the failures happened due to subsequent traumatic injuries sustained during the healing phase after implant placement
3. Adverse effects of implants in children and adolescents (India)	11 adolescents (7boys and 4 girls)	**Maxillary anterior** **Mandibular anterior**	06 cases of infra-occlusion No report about a failure in the form of pain/paresthesia , mobility or peri-implant radiolucency
4. Six-Year survival of a mini dental implant-Retained overdenture in a child with ED (Turkey)	A boy	**Mandibular anterior canine region**	No evidence observed of intensive resorption in the peri-implant bone No functional and esthetic problems

5. Rehabilitation of ectodermal dysplasia patients presenting with hypodontia: outcomes of implant rehabilitation part 1 **(Australia)**	6 patients(4 patients under <18years) :3boys and 2 girls	**Mandibular anterior region**	Good scores of visual analogue scale of :aesthetics ,chewing, diet restriction and speech after treatment Encouraging outcomes
6. Dental implants in growing patients: A quality assessment of systematic reviews(India)	Children under 17 years	**Mandibular and maxillary anterior regions**	Complication of infra-occlusion
7. Commentary on mini dental implant insertions in children with ED(Italy)	Kids between 3 to 18 years	**Mandibular anterior region**	Positive impact of mini implants on oral function
8. **Implant-supportedoral rehabilitation in child with ED** **(Brazil)**	A female patient	**Mandibular anterior region**	Restoration of masticatory ,phonetic and esthetic function Enhancing the patient's self-esteem and overall social well-being
9. Implant Failure in Young children with ED: A retrospective evaluation of use and outcome of dental implant treatment in children **(Sweden)**	26 children below age 16(18 girls and 08 boys)	**Maxillary(agenesies and trauma)** **Mandibular anterior region(ED)**	Complication of lost implants was repported High implants survival rate after 05 years of follow up

10. Dental implant therapy for a child with X-linked hypohidrotic Ed(Sweden)	A boy	**Mandibular anterior region**	Osteointegrated implants after over 25 years of follow up Satisfaction of patient with his denture was reported
11. Hypohidrotic ectodermal dysplasia: dental clinical, genetic and dermatoglyphic findings of three cases(Turkey)	03 patients (01 girl et 02 boys)	**Mandibular anterior region**	Osteointagrated implants were showed Rehabilitation of the oral conditions of the children
12. Dental implants in children : a multidisciplinary perspective for long-term success review (India)	256patients	**Mandibular anterior region** **Maxillary anterior region**	Multidisciplinary approach is necessary Improving masticatory and esthetic The alveolar bone assessment is carried out through coputed tomography (CT) or cone beam Osteointegrated implant and no implant failures were reported Follow up :03 years
13. Pre-implant surgery comlexity for achieving implant – supported prosthetic rehabilation in oligodontia	119 patients (4 patients under <18 years)	**Maxilla/ mandible**	Good osteointegrated implants were showed after 03 years

patients (France)			
14. Mini implants: Alternative for oral rehabilitation of a child with ED(Brazil)	A girl with hypodontia	**Mandibular anterior region**	Good adaptation of dental prosthesis and satisfaction with treatment . Follow up :06 months

The anterior mandible is the most recommended site for early implant placement in children due to its early growth completion and stable bone structure.

Tableau VII: According to the implant details:

Article title	Patients number	Implant placement details	Conclusion
1. Pediatric dental implant(India)	Youngster at age of 02 years	**02 endosseous implants**	Good esthetic and fuctinal results Multidiscipliary approach
2. Use of dental implants in children(Brazil)	35 patients	**42 endosseous implants**	Positive soft and osseous tissue reaction to the implants Most of the failures happened due to subsequent traumatic injuries sustained during the healing phase after implant placement

3. Adverse effects of implants in children and adolescents(India)	11 adolescents (7boys and 4 girls)	**16 implants: 15 maxillary one mandibular** **Type:Bonefit,ITI,3i,Calcitek and Sustain** **Length :10-15mm** **Diameter:3,25-4mm**	06 cases of infra-occlusion No report about a failure in the form of pain/paresthesia , mobility or peri-implant radiolucency
4. Six-Year survival of a mini dental implant-Retained overdenture in a child with ED(Turkey)	A boy	**02 mini-implants (Endure MDI/ImtecCorp,3M ESPE,St.Paul,MN)** **Diameter:2.9 mm** **Length:13mm**	No evidence observed of intensive resorption in the peri-implant bone No functional and esthetic problems
5. Rehabilitation of ectodermal dysplasia patients presenting with hypodontia: outcomes of implant rehabilitation part 1(Australia)	6 patients(4 patients under <18years) :3boys and 2 girls	**17implants mandibular implants Diameter :3,75-5mm** **Length :8,5-13** **Type:Branemark MK** **III TiUnite, Nobel Biocare**	Good scores of visual analogue scale of :aesthetics ,chewing, diet restriction and speech after treatment Encouraging outcomes
6. Dental implants in growing patients: A quality assessment of systematic reviews(India)	Children under 17years	**6 to 493 implants** **Type: Bonefit, ITI, 3i implant, Nobel Biocare, Straumann AG, Denstply Frialit, Branemark System, IMZ Pressfit, Interpore, MTI transitional implant etc**	Complication of infra-occlusion

7. Commentary on mini dental implant insertions in children with ED(Italy)	Kids between 3 to 18 years	**Mini-implants**	Positive impact of mini-implants on oral function Improving stability
8. Implant-supportedoral rehabilitation in child with ED(Brazil)	A female patient	**04 implants** **Diameter :3,75 -4mm** **Length :11 mm**	Restoration of masticatory, phonetic and esthetic function Enhancing the patient's self-esteem and overall social well-being
9. Implant Failure in Young children with ED: A retrospective evaluation of use and outcome of dental implant treatment in children(Sweden)	26 children below age 16(18 girls and 08 boys)	**33 impalnts (agenesies and trauma groups)** **14 implants (ED)** **Type:Branemark system (Nobel Biocare,Goteborg ,Sweden)** **Length:10-13mm** **Varying diamters**	Loss of 2 implants in agenesis and trauma groups (6,1%) and of 9 implants in ED group (64,3%)
10.Dental implant therapy for a child with X-linked hypohidrotic Ed(Sweden)	A boy	**02 implannts** **Type :Branemark** **Length ;10-13mm** **Diamter :3,75mm**	Patient at 7years received 02 implants.

11. Dental implants in children : a multidisciplinary perspective for long-term success review (India)	256patients	**278implants** **Type:Ha- titanium (Ti) implant system** **Length : 12–16 mm** **Diameter: 3.5- 4.0 mm**	Multidisciplinary approach is necessary Improving masticatory and esthetic The alveolar bone assessment is carried out through computed tomography (CT) or cone beam Osteointegrated implant and no implant failures were reported Follow up :03 years
12. Pre-implant surgery complexity for achieving implant –supported prosthetic rehabilitation in oligodontia patients (France)	119 patients (2 patients under <18 years)	**08 implants** **Lengths : 8 -14 mm** **Diamter:3.3-4,7mm**	Good osteointegrated implants were showed after 03 years
13. Mini implants: Alternative for oral rehabilitation of a child with ED(Brazil)	A girl with hypodontia	**02 mini-implants** **Length :10 mm** **Diameter 1.6 mm** **Type:Morelli, Sorocaba, SP, Brazil**	Absence of bone resorption in the symphysis area after a 6-year follow-up

Authors recommended both conventional implants and mini dental implants in children, depending on age, bone availability, and growth stage. While mini implants are ideal for early, less invasive intervention, conventional implants are better suited for post-growth placement, with success relying on careful case selection and growth monitoring.

Tableau VIII: according to the type of prosthodontic designed

Article title	Patients number	Type of prosthesis designed	Conclusion
1. Pediatric dental implant (India)	Youngster at age of 02 years	**Implant-supported overdenture**	Multidisciplinary approach is necessary Good esthetic and functional results of osteointegrated implant Mandibular implant-supported overdenture was well tolerated after 03 years of follow up
2. Use of dental implants in children(Brazil)	35 patients	**Implant-supported overdenture**	Positive soft and osseous tissue reaction to the implants Most of the failures happened due to subsequent traumatic injuries sustained during the healing phase after implant placement

			Infra-occlusion was reported as a complication Follow up :5 years
3. Adverse effects of implants in children and adolescents(India)	11 adolescents (7boys and 4 girls)	**Implant- supported prosthesis**	No report about a failure in the form of pain/paresthesia , mobility or peri-implant radiolucency Good osseointegration was observed 06 cases of infra-occlusion Follow up :4-5 months to 13 years
4. Six-Year survival of a mini dental implant-Retained overdenture in a child with ED(Turkey)	A boy	**Maxillary removable partial prosthesis** **A mini implant-retained mandibular overdenture**	During the 6 year of follow up period ,no evidence observed of intensive resorption in the peri-implant bone No functional and esthetic problems
5. Rehabilitation of ectodermal dysplasia patients presenting with hypodontia: outcomes of implant rehabilitation part 1 **(Australia)**	6 patients(4 patients under <18years) :3boys and 2 girls	**Implant supported fixed partial denture** **Maxillary removable partial denture**	Good scores of visual analogue scale of :aesthetics ,chewing, diet restriction and speech after treatment Encouraging outcomes Follow up : 1- 7 years

6. Dental implants in growing patients: A quality assessment of systematic reviews(India)	Children under 17 years	**Single crowns - bilateral fixed prosthesis or complete implant supported dentures**	Complication of infra-occlusion
7. Commentary on mini dental implant insertions in children with ED(Italy)	Kids between 3 to 18 years	**Implant supported prosthesis**	Mini implants improve the stability which has positive impact on oral function. Follow up :1-20years
8. Implant-supportedoral rehabilitation in child with ED(Brazil)	A female patient	**Implant – supported mandibular ovedenture Maxillar removable partial denture**	Restoration of masticatory ,phonetic and esthetic function Enhancing the patient's self-esteem and overall social well-being Follow up : 04 years
9. Implant Failure in Young children with ED: A retrospective evaluation of use and outcome of dental implant treatment in children(Sweden)	26 children below age 16(18 girls and 08 boys)	**Implant- supported overdentures and crowns**	Complication of lost implants was reported High implants survival rate after 05 years of follow up
10.Dental implant therapy for a child with X-linked hypohidrotic Ed(Sweden)	A boy	**Maxillary removable dental prosthesis** **Mandibular implant-supported overdenture**	Osteointegrated implants after over 25 years of follow up Satisfaction of patient with his denture was reported

11.Hypohidrotic ectodermal dysplasia: dental clinical, genetic and dermatoglyphic findings of three cases(Turkey)	03 patients (01 girl et 02 boys)	**Fixed maxillary denture** **Mandible implant-supported denture**	Osteointagrated implants were showed Rehabilitation of the oral conditions of the children
12. Dental implants in children : a multidisciplinary perspective for long-term success review (India)	256patients	**Mandibular implant supported overdenture** **Maxillary conventional overdenture**	Multidisciplinary approach is necessary Improving masticatory and esthetic The alveolar bone assessment is carried out through computed tomography (CT) or cone beam Osteointegrated implant and no implant failures were reported Follow up :03 years
13. Pre-implant surgery comlexityfor achieving implant supported prosthetic rehabilationinoligodontia patients(France)	119 patients (02 patients under <18 years)	**Mandibular implant supported overdenture**	Good osteointegrated implants were showed after 03 years
14. Mini implants: Alternative for	A girl with hypodontia	**Mandibular mini-implants**	Good adaptation of dental prosthesis and

oral rehabilitation of a child with ED(Brazil)		**supported denture** **Maxillary partial removable denture**	satisfaction with treatment. Follow up :06 months

Implant-supported overdentures, particularly in the anterior mandible, are the most effective and adaptable prosthetic option for growing children, offering both functional and esthetic benefits. Fixed prostheses are generally deferred until growth completion, while removable dentures serve as common interim solutions despite their limitations.

IV. *DISCUSSIONS:*

1. *According to the etiology:*

This discussion synthesizes findings from 14 selected articles to explore how the etiology of edentulism whether congenital, traumatic, or ectodermal dysplasia influences the success of dental implant placement in children. Among these 14 articles:

- 28% of articles focus on the non-syndromic etiology of edentulism, including trauma, oligodontia, and non-syndromic agenesis.
- 72% of articles explore the ectodermal dysplasia as an etiology of edentulism

Trauma-related cases consistently demonstrate the most favorable outcomes for dental implant placement in children, while syndromic conditions such as ectodermal dysplasia (ED) present the greatest clinical challenges. In trauma cases, as reported by *Bergendal et al.*(2008) (97) children aged 12 to 15 who received implants following the completion of jaw growth exhibited a 100% success rate. This high success is largely attributed to the presence of normal, well-developed alveolar bone prior to injury and the absence of systemic or syndromic complications, which allows for predictable healing and reduces surgical risk (60)

Furthermore, delayed implant placement in these cases, after skeletal maturity, minimizes growth-related complications such as infra-occlusion. Conversely, implant survival in children with ED is notably variable, ranging from approximately 35% to complete success, contingent upon factors such as anatomical limitations, timing of placement, and the comprehensiveness of care strategies. *Bergendal et al.* (2008) (97) reported a failure rate of 64.3% in ED patients aged 5 to 12, with contributing factors including small jaw dimensions, dense cortical bone, and premature placement. Children with ED typically exhibit severe hypodontia or anodontia, underdeveloped ridges, delayed craniofacial growth, and compromised soft tissues conditions that collectively hinder implant integration and healing. Moreover, ED affects not only the dentition but also the sweat glands, skin, and mucosal tissues, increasing the risk of postoperative complications. However, evidence from long-term follow-ups, such as the case documented by *Bergendal et al*. (2015), (24) suggests that early success is attainable when treatment is carefully staged and supported by meticulous hygiene and interdisciplinary planning. Oligodontia represents an intermediate clinical scenario; while it shares developmental constraints with ED, implant outcomes are generally more predictable when early diagnosis and multidisciplinary planning are followed by surgical intervention after growth completion. Lauwers et al. (98) emphasize that initiating treatment coordination in childhood significantly improves success rates in post-growth patients.

In summary, the etiology of tooth loss is a critical determinant of implant prognosis in children: trauma cases benefit from optimal anatomical and developmental conditions; oligodontia responds well to delayed, coordinated care and ED requires individualized, staged approaches to address complex anatomical and systemic challenges. Understanding these etiological differences is essential for formulating effective, growth-sensitive implant treatment plans in pediatric dentistry.

2. *According to the age:*

This discussion aims to explore the appropriate timing for dental implant placement in children, a topic of ongoing debate due to the complexity of growth and development in pediatric patients. Based on a review of 14 selected scientific articles, this analysis focuses on identifying the optimal age or developmental stage for implant placement.

64% of the articles (9 out of 14) agree that dental implant placement should be postponed until skeletal and dental growth is nearly complete. According to *Gholap et al*., 2022**(99)**, as well as others , implant therapy should ideally be deferred until growth is complete—typically around 15 years in girls and 17 years in boys**(100)**. This delay helps avoid complications such as infra-occlusion, implant submergence, malpositioning, rotational disturbances, and unfavorable angulation, which are most likely when implants are placed during active eruption phases of adjacent teeth.

50% of the articles (7 out of 14) discuss implant and mini-implant placement in children with ectodermal dysplasia, emphasizing that early intervention—particularly in the anterior mandible—can be both feasible and necessary to address prosthetic, functional, and psychological needs. These cases are always managed through multidisciplinary, individualized treatment planning to ensure long-term success.

- Examples include:

A successful case of implant placement at age 5 **(99)**, though prosthetic adjustments were needed.

Another case reported functional implant stability for over two decades when placed at 6 years and 5 months**(24)**

The Delphi consensus supports implant placement as early as 7–8 years in select ED cases (101)

Despite isolated successful cases, 14% of the articles (2 out of 14) reported increased failure rates up to 64.3% in children under age 12 with ectodermal dysplasia. These failures were mainly due to limited bone volume and surgical challenges, not necessarily the syndrome itself. As a result, *Bergendal et al.* and others recommend delaying implantation until the jaw has developed enough to support stable healing and osseointegration.

In addition, a study on oligodontia **(98)**concluded that early placement may interfere with jaw development, increase surgical burden, and raise the risk of implant failure or malocclusion.

36% of the articles (5 out of 14) explicitly state that there is no universally ideal chronological age for implant placement, due to variability in craniofacial development among children. This supports the use of growth assessments.

Finally, they emphasize that success may be improved by: delaying treatment until growth stabilizes; using narrower implants and centralizing care in multidisciplinary, specialized pediatric centers with expertise in implant rehabilitation.

3. According to the evaluation of growth:

Among the 14 reviewed articles on dental implants in children, only three specifically addressed the evaluation of craniofacial growth as a key factor in treatment planning.

Growth evaluation is essential in pediatric implantology because improper timing can lead to complications; The three articles discussed this topic.

Among the 14 reviewed articles on dental implants in children, only three specifically addressed the evaluation of craniofacial growth as a key factor in treatment planning. Growth evaluation is essential in pediatric implantology because improper timing can lead to complications such as infraocclusion, implant submergence, and misalignment. The three reviewed articles consistently emphasize the importance of growth assessment when planning dental implant treatment in children. Serial lateral cephalometric analyses provide essential insights into skeletal development, particularly through indicators like the ANB angle, which measures the sagittal relationship between the maxilla and mandible. In a long-term case involving a child with X-linked hypohidrotic ectodermal dysplasia (XL-HED), the ANB started at +1.5° at 7 years 5 months, a value close to the normative mean of +2° (±1–2°), indicating a balanced Class I relationship. By age 10 years 4 months, the ANB had shifted to –1°, reflecting a developing Class III pattern due to mandibular overgrowth. This trend continued into adulthood, with the ANB stabilizing at –2°, confirming a compensated skeletal Class III relationship. Despite these changes, functional and aesthetic outcomes were maintained through prosthetic adjustments, such as the use of angulated abutments, highlighting the importance of ongoing growth monitoring. Similarly, in the case presented by *Kilic et al.* (2015), periodic cephalometric evaluations over a six-year period allowed for timely prosthetic renewal, ensuring that the implant-supported overdenture remained compatible with jaw development and did not interfere with natural tooth eruption. Although the ANB angle was not reported in this case, structured growth monitoring enabled successful long-term prosthetic adaptation. Notably, in both cases, the authors placed implants outside the peak pubertal growth phase—which typically occurs between ages 10–15 in girls and 12–17 in boys—to avoid complications associated with ongoing skeletal changes and to ensure better implant stability and integration. Together, these cases underscore that systematic growth assessment—using ANB angle tracking, cephalometric analysis, and hand–wrist radiographs—is essential for anticipating skeletal changes, planning optimal implant timing, and achieving long-term prosthetic success in growing patients. Ultimately, the success of dental implants in children is closely tied to the clinician's ability to evaluate and respond to individual growth patterns throughout the treatment timeline.

4. *According to the sector of implantaton:*

The success of dental implants in pediatric patients is closely related to the anatomical region selected for placement (102).

Approximately 75% of the reviewed articles support the anterior mandibular region as the most favorable site for early implant placement in children, particularly in cases of congenital conditions like ectodermal dysplasia. This high consensus is based on the anatomical and developmental advantages of the anterior mandible, such as early symphyseal fusion, limited post-pubertal growth, and adequate bone volume for osseointegration. Additionally, transverse growth in this area stabilizes around the age of 6 to 7 years (101), allowing for earlier and more predictable implant integration compared to other regions.

Implants in the anterior mandible have shown excellent long-term outcomes, even when placed as early as 5 to 6 years of age (103) (104). For instance, *Kilic et al.* demonstrated a successful 6-year follow-up in a child with ectodermal dysplasia who received two mini-implants in the mandibular canine region (36). Other reports also favored parasymphyseal sites (canine and premolar regions) due to their structural stability and potential for supporting fixed prostheses. Despite challenges like dense bone or small jaw size in young children, implants in this sector consistently yielded functional and esthetic success, especially with multidisciplinary planning (31).

In children with ectodermal dysplasia, the anterior mandibular symphysis is the preferred site for mini dental implants due to its good bone support, easy access, and low impact on facial growth, making it suitable for stable placement in cases of severe tooth agenesis (98).

In contrast, the anterior maxillary region was identified as a higher-risk site by several sources. This is attributed to ongoing sagittal, vertical, and transverse growth in the maxilla, which can lead to infra-occlusion, implant displacement, or even nasal floor perforation over time. Implants in this sector can also interfere with the midpalatal stuture; potontially restricting transverse growth (31)

The systematic review by *Kamatham et al.* reported that although most implants in their sample were placed in the maxillary anterior region, infra-occlusion was significantly more common in this area, especially in long-term follow-ups. Due to these risks, implantation in the anterior maxilla is generally postponed until after skeletal maturity, usually 15 years for girls and 17 for boys.

The posterior maxilla and mandible were found to be even less ideal due to ongoing multidirectional growth and remodeling, including alveolar bone apposition and rotational changes of the jaws, which may result in implant misalignment or functional issues.

Overall, the region of implant placement plays a decisive role in clinical success, with the anterior mandible showing the highest predictability and success rates, and maxillary and posterior regions posing greater risks due to their continuous developmental changes.

5. According to the details of implant

The types of dental implants used in children across the reviewed studies varied primarily in brand, diameter, and length, reflecting adaptations to pediatric anatomical limitations.

The *Brånemark* system was the most frequently reported, used in approximately 60% of the studies, particularly in cases involving ectodermal dysplasia. These implants commonly had diameters of 3.3 mm to 3.75 mm and lengths ranging from 10 mm to 13 mm, and were typically placed in the anterior mandible due to its relatively stable growth pattern.

Straumann SLActive Bone Level implants were used in about 20% of the studies, with diameters ranging from 3.3 mm to 4.1 mm, while Implant Innovations (3i) systems and *Biomet* 3i Osseotite implants were each used in approximately 10% of the reports, some with lengths up to 15 mm. The use of narrow-diameter implants (3.0–3.5 mm) was common due to reduced bone volume in pediatric patients. Despite the variety of systems used, no single implant type consistently outperformed others in terms of clinical success.

Implant failures—especially in younger children with small jaws—were more commonly attributed to surgical conditions, bone quality, and developmental factors rather than the implant system itself. Overall, although all implant systems discussed are well established in adult practice, their successful use in children required careful adjustment to anatomical constraints and growth patterns, rather than dependence on a specific implant brand(36, 60, 105)2 articles discuss the use of dental implants in children but do not provide specific information about implant brands or diameters. Instead, they emphasize that the success of implants in pediatric patients is primarily influenced by anatomical location, growth status, and prosthetic design rather than the technical specifications of the implant itself. For example, in one case, two tapered screw-type endosseous implants were placed in the anterior mandible of an 11-year-old child with ectodermal dysplasia, using ball attachments to allow flexibility and accommodate jaw growth, resulting in successful function and aesthetics over a three-year follow-up. Another study reviewed 42 implants placed in children aged 9 to 18 years, reporting a 90% success rate, with most failures due to trauma during healing and growth-related complications like submergence and infraocclusion, not implant type (100, 102) .

In 3 reviewed cases reports involving children with ectodermal dysplasia, mini dental implants (MDIs) were successfully used to support prosthetic rehabilitation. In the most detailed clinical case, a 6-year-old child received two Endure MDI/Imtec Corp (3M ESPE) mini-implants, each 2.9 mm in diameter and 13 mm in length, placed in the anterior mandible. These implants demonstrated stable osseointegration and excellent functional and esthetic outcomes over a 6-year follow-up period, with no peri-implant bone resorption or prosthetic complications. Another case report described a 9-year-old girl treated with two 1.6 mm diameter, 10 mm long mini-implants (Morelli, Brazil), which significantly improved prosthesis retention, masticatory function, and speech. These reports emphasize that mini-implants provide a minimally invasive alternative when alveolar bone volume is insufficient for standard implants, especially in children with ED. Additionally, the small diameter and surgical simplicity of MDIs enhance patient cooperation and comfort. However, all studies caution that regular monitoring and potential prosthesis replacement are necessary to adapt to growth-related changes. Thus, success is more related to clinical adaptation, implant placement site, and follow-up, rather than the specific implant brand .

According to the articles reviewed, both conventional dental implants and mini dental implants (MDIs) have been used in children with ectodermal dysplasia, but they differ notably in suitability and application. Conventional implants often require sufficient alveolar bone volume and involve more invasive surgical procedures, which can be challenging in children due to ongoing growth and underdeveloped bone structures. In contrast, MDIs, as reported in the cases by *Kilic et al. and Mello et al.*, offer a less invasive alternative, requiring less bone and simpler placement. For example, *Kilic et al*. described a 6-year-old child successfully rehabilitated with two MDIs (2.9 mm × 13 mm) with stable function over six years, while

Mello et al. reported improved prosthetic retention and patient satisfaction using MDIs of 1.6 mm diameter and 10 mm length. The articles highlight that MDIs are particularly advantageous in young patients because of reduced surgical complexity, better patient cooperation, and fewer anatomical constraints. However, they also note the need for regular follow-up due to growth-related changes. Overall, the articles suggest that while both types of implants can be effective, MDIs may offer a more adaptable and practical solution for pediatric cases with limited bone volume and active growth.

6. According to the prosthodontic designed

The selection of an appropriate prosthetic solution in pediatric patients presents unique clinical challenges due to ongoing craniofacial growth, psychological development, and functional demands; this discussion explores the various types of prostheses used in children—removable dentures, implant-supported overdentures, fixed implant-supported restorations, and mini dental implants—highlighting their indications, benefits, limitations, and reported clinical outcomes.

According to *Gholap et al*., the type of prosthesis used in pediatric dental implant therapy significantly influences the success and adaptability of treatment during growth. Among the different designs, implant-supported overdentures are reported as the most successful and commonly used prosthetic solution in children, particularly those with ectodermal dysplasia. These prostheses, typically placed in the anterior mandible, often utilize ball attachments that avoid rigid fixation, allowing for mandibular growth and minimizing interference with developing craniofacial structures. Their retrievability and capacity for modification make them ideal for accommodating vertical and sagittal changes during childhood. This was supported by 43% of the cited articles (36, 97, 101) .

For example, *Kilic et al*. reported a successful six-year follow-up of a mini dental implant-retained mandibular overdenture in a 6-year-old child, with excellent esthetic and functional results and no complications(36). Similarly, *Göker and Çubukçu*, emphasized the effectiveness of mini dental implants (MDIs) in improving oral function, esthetics, and overall quality of life (106, 107).

In contrast, fixed prostheses were reported as less suitable during early childhood in 29% of the articles, due to the risks of infra-occlusion, misalignment, and interference with alveolar bone growth (60, 101). *Bergendal et al* observed a high failure rate (64.3%) in children who received mandibular implant-supported prostheses before age 7, with most implants lost before loading (97). However, a 2015 follow-up case (Article 10) showed long-term success using a combination of removable and implant-supported prostheses from an early age. *Kamatham et al*. also noted the use of single-unit endosseous implants in children with tooth loss due to trauma or caries, which showed good short-term success but carried a long-term risk of infra-occlusion (60). Another article further reinforced this limitation, stating that fixed options should be deferred until growth completion to prevent developmental disturbances (101).

Removable dentures were mentioned in 43% of the articles as common interim or initial solutions, particularly during early growth stages, and were often introduced around age 3 in cases of severe hypodontia or anodontia. While removable prosthodontics are widely used for their simplicity and early applicability, many studies noted limitations, such as poor retention, frequent need for adjustment, and reduced long-term effectiveness. Article 6 also underlined their psychological and social benefits, helping to improve speech, appearance, and patient self-esteem, despite their mechanical drawbacks.

Finally, only 7% of the cited articles supported the use of fixed implant-supported prostheses as the preferred long-term solution after growth completion, particularly in cases of oligodontia, where they offer a stable and functional outcome that integrates well into a multidisciplinary treatment plan (98).

Conclusion

The management of edentulism in pediatric patients, particularly through the use of dental implants, involves a complex interplay of anatomical, developmental, technical, and prosthetic factors. Across the six domains reviewed—etiology, implant placement, age of implantation, implant design, growth evaluation, and prosthodontic approach—a recurring theme emerges: successful outcomes in children require precise planning tailored to the individual's medical condition, skeletal development, and prosthetic needs.

Etiological, children with congenital conditions such as ectodermal dysplasia present unique anatomical and functional challenges compared to those with tooth loss due to trauma or non-syndromic agenesis. These differences significantly influence treatment timing and implant selection. The region of implant placement is equally important, with the anterior mandible consistently identified as the most stable and reliable site for early intervention due to its early cessation of transverse growth and favorable bone volume. Conversely, the anterior maxilla and posterior regions carry higher risk due to ongoing multi-directional growth and proximity to critical anatomical structures.

Timing of implantation remains a nuanced decision. While traditional guidelines advocate delaying until skeletal maturity, many studies support earlier placement in carefully selected cases, especially when functional, esthetic, or psychosocial needs are significant. These early interventions are only recommended when supported by reliable indicators of skeletal maturity, such as serial cephalometric or hand–wrist radiographs, underscoring the importance of thorough growth evaluation. Implant selection—whether standard diameter or mini-implants—must be adapted to the child's bone morphology and space availability, with mini implants offering a minimally invasive alternative in cases with restricted anatomy.

Finally, prosthodontic strategies must remain adaptable throughout the child's development.

Removable prostheses and implant-supported overdentures, particularly those designed with flexible components like ball attachments, are preferred during growth periods to allow ongoing modification. Fixed prostheses, while functionally desirable, are generally deferred until growth has stabilized to avoid complications such as infra-occlusion or implant misalignment.

In integrating these considerations, it becomes clear that implant therapy in pediatric cases is not defined by a single protocol but by a constellation of individualized clinical decisions, each informed by a multidisciplinary understanding of growth, anatomy, and prosthetic function. This comprehensive approach is essential for optimizing both short- and long-term outcomes in the dynamic context of the developing child.

7. Recommendations:

Taking into account the findings of this literature review, which underscore the success of implant-supported prosthetic treatment in children, we propose a series of clinical recommendations to guide practitioners involved in pediatric dental care:

1. Delay implant placement in child until skeletal maturity is confirmed, typically around 15years in girls and 17 in boys
2. Dental implant placement in children is feasible outside periods of peak growth (12-17years for boys and 10-15 years for girls).
3. Evaluate skeletal growth using serial cephalometric through indicators like the ANB angle;the normative mean of +2° (±1–2°,) and hand–wrist radiographs to ensure optimal implementing and long-term success.

4. Prioritize individualized treatment planning based on the etiology of edentulism, especially in syndromic cases like ectodermal dysplasia.
5. Select the anterior mandible as the preferred implant site in growing children due to its early stabilization and minimal growth interference.
6. Choose implant dimensions based on available bone volume, with either endosseous or mini-implants providing a suitable option in anatomically limited cases and the possibility of subsequent re-implantation.
7. use of implant-supported overdenture retained two symphyseal implants in the anterior region if the mandible; with two Ball- attachments connected, reserving fixed prostheses for post-growth rehabilitation.
8. In order to guarantee implant success, care must be multidisciplinary (oral surgeon, prosthodontist, orthodontist and pediatric dentists).

V. *CONCLUSION AND PERSPECTIVES*

Oral implantology in children currently represents a rapidly evolving therapeutic field, situated at the intersection of functional, aesthetic, and psychological imperatives. While craniofacial growth has long been a major obstacle to implant placement in this population, the gradual accumulation of clinical data now allows for the consideration of targeted and rigorously regulated indications, emerging as a feasible, even necessary, therapeutic option, particularly in cases of severe agenesis, traumatic tooth loss, or syndromic pathologies such as ectodermal dysplasia (ED). These clinical situations result in significant impairment of masticatory function, facial aesthetics, and psychological well-being, often rendering conventional removable prosthetic solutions unsuitable.

It is also evident that etiology plays a fundamental role in implant success. Trauma-related cases show the highest survival rates due to normal bone anatomy and timing of placement after growth. Non-syndromic oligodontia cases demonstrate high success when multidisciplinary planning begins early but surgical intervention is postponed. In contrast, ectodermal dysplasia presents more complex anatomical and systemic challenges, with implant success heavily dependent on timing, site selection, and individualized prosthetic design. Even in such syndromic cases, favorable outcomes are achievable with careful case selection, staged treatment, and long-term follow-up.

A central finding throughout this work is the importance of growth evaluation. Serial cephalometric analyses, particularly tracking the ANB angle and using hand–wrist radiographs, allow clinicians to monitor the child's skeletal maturation and to determine the optimal timing for implant placement. Most authors agree that implants should be placed outside the period of peak pubertal growth, which typically occurs between 10–15 years in girls and 12–17 years in boys, to minimize complications such as infra-occlusion, implant submergence, and misalignment. Proper timing not only improves osseointegration and prosthetic stability but also ensures long-term esthetic and functional outcomes.

From a surgical standpoint, the anterior mandible is unanimously regarded as the most favorable site for implant placement during childhood. This region shows early transverse growth stabilization (around age 6–7), minimal post-pubertal remodeling, and sufficient bone density, making it ideal for both conventional implants and mini dental implants (MDIs). In contrast, the anterior maxilla and posterior regions present significantly higher risks due to prolonged growth and the presence of critical anatomical structures, and are therefore often avoided until skeletal maturity is reached.

In terms of prosthetic rehabilitation, implant-supported overdentures—especially those retained by two mini-implants with ball attachments in the anterior mandible—emerge as the most reliable and adaptable solution during the growth period. These designs allow for removability, maintenance, and periodic adjustment in response to vertical and sagittal growth changes. Their simplicity, reversibility, and functional benefits make them particularly well-suited for children with ectodermal dysplasia, oligodontia, or post-traumatic tooth loss**.** Although fixed prostheses can provide superior esthetics and stability, they are generally deferred until after growth completion due to the risks of occlusal disharmony and interference with alveolar development.

Throughout the dissertation, one recurrent theme is the importance of a multidisciplinary approach. Successful pediatric implant treatment relies on collaboration between pediatric dentists, oral surgeons, orthodontists, prosthodontists, and, when necessary, geneticists and psychologists. This team-based model ensures not only precise surgical and prosthetic planning, but also emotional support and long-term monitoring as the child transitions into adolescence and adulthood.

In conclusion, the placement of dental implants in children is both clinically feasible and beneficial, provided that treatment is based on thorough growth evaluation, appropriate timing, precise anatomical site selection, and adaptable prosthetic planning. Rather than being viewed as a contraindication, childhood should be regarded as a critical window for establishing oral function, facial aesthetics, and psychological well-being—goals that implant therapy can help achieve when delivered responsibly and individually. As clinical protocols and implant technology continue to evolve, pediatric dental implants are poised to become an integral part of comprehensive oral rehabilitation in selected young patients.

Perspectives:

1. Standardization of Clinical Protocols: define optimal age for implant placement, safe anatomical zones, and precise indications for pediatric patients;
2. Development of Growth-Adaptive Implants: design modular, reversible implant systems suited to the developing bone and adaptable to future anatomical changes;

3. Personalized Digital Monitoring: use 3D scanning, growth simulation tools, and artificial intelligence to adjust prosthetic designs over time;
4. Reinforced Ethical and Psychological Approach: ensure informed consent and evaluate the psycho-social impact of early implant rehabilitation on the child and family;
5. Exploration of Minimally Invasive Alternatives (e.g., MDIs): favor less invasive techniques that offer good primary stability, while encouraging long-term studies to validate their efficacy;
6. Systematic Multidisciplinary Coordination: promote close collaboration between surgeons, orthodontists, pediatric dentists, and psychologists for comprehensive treatment planning.

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ABSTRACT:

Dental implant placement in growing children is a delicate procedure due to the potential impact on craniofacial development and the evolving nature of bone structures.
This study aimed to assess the clinical feasibility of dental implant placement in pediatric patients.

A systematic literature review was conducted using PubMed, ProQuest, and ScienceDirect, covering the period from 2000 to 2025. Keywords were based on MeSH terms related to 'Pediatric Dental Implant'.

15 relevant articles were selected and analyzed based on clinical parameters:

- Etiology: Ectodermal dysplasia is the most frequently reported condition.
- Age: Implantation is reported as early as age 6.
- Region: The mandibular symphysis is the most stable site.
- Growth: Assessed via ANB angle (cephalometry) and wrist X-ray.
- Implant Type: Mostly endosseous, mini-implants (MDIs) used in complex cases.
- Prosthetic Design: Overdentures are the most common.

Implant placement is feasible in children depending on the clinical case and with careful multidisciplinary evaluation.

RESUME :

La pose d'implants dentaires chez les enfants en croissance est une procédure délicate en raison de l'impact potentiel sur le développement cranio-facial et de l'évolution des structures osseuses.

Cette étude visait à évaluer la faisabilité clinique de la pose d'implants dentaires chez les patients pédiatriques.

Une revue systématique de la littérature a été réalisée en utilisant PubMed, ProQuest et ScienceDirect, couvrant la période de 2000 à 2025. Les mots-clés étaient basés sur les termes MeSH liés aux "Implants dentaires pédiatriques".

15 articles pertinents ont été sélectionnés et analysés selon des paramètres cliniques :

- Étiologie : La dysplasie ectodermique est la pathologie la plus fréquemment rapportée.
- Âge : La pose d'implants est rapportée dès l'âge de 6 ans.
- Région : La symphyse mandibulaire est le site le plus stable.
- Croissance : Évaluée via l'angle ANB (céphalométrie) et la radiographie du poignet.
- Type d'implant : Principalement endo-osseux, avec des mini-implants (MDIs) utilisés dans les cas complexes.
- La prothèse conçue : Les overdentures sont les plus courantes.

La pose d'implants est réalisable chez les enfants selon le cas clinique, sous réserve d'une évaluation multidisciplinaire rigoureuse.

ملخص:

يعد وضع الغرسات السنية لدى الأطفال في مرحلة النمو إجراءً دقيقًا بسبب التأثير المحتمل على تطور القحف الوجهي وطبيعة الهياكل العظمية المتغيرة.

تهدف هذه الدراسة إلى تقييم الجدوى السريرية لوضع الغرسات السنية لدى المرضى الأطفال.

تم إجراء مراجعة منهجية للأدب باستخدام قواعد بيانات PubMed و ProQuestوScienceDirect، لتغطية الفترة من عام **2000 إلى 2025. واستندت الكلمات المفتاحية إلى مصطلحات MeSH المتعلقة بـ"الغرسات السنية للأطفال."

تم اختيار 15 دراسة ذات صلة وتحليلها بناءً على المعايير السريرية التالية:

- السبب المرضي: خلل التنسج الأديمي الظاهر هو الحالة الأكثر شيوعًا.
- العمر: تم الإبلاغ عن عمليات زرع في سن مبكرة تصل إلى 6 سنوات.
- المنطقة: تعتبر **السيمفيز الفكي السفلي أكثر المواقع ثباتًا.
- النمو: تم تقييمه عبر زاوية) ANB قياس الرأس) و أشعة سينية للرسغ.
- نوع الغرسة: في الغالب غرسات داخل العظم، مع استخدام الغرسات الصغيرة (MDIs) في الحالات المعقدة.
- تصميم التعويض السني: التركيبات فوق الغرسات (Overdentures) هي الأكثر شيوعًا.

يعد وضع الغرسات السنية ممكنًا لدى الأطفال حسب الحالة السريرية، بشرط إجراء تقييم متعدد التخصصات بدقة.