Introduction and Problem Definition

Agenesis with a prevalence of 5.5% of the entire population together with primary or secondary irreversible tooth loss following trauma are the most prevalent causes of gaps between upper anteriors in children and adolescents [1]. These missing teeth result in a range of consequences, which, in addition to limited function, include development of the alveolar process, aesthetics and the psychosocial development of the children or adolescent patients.

The limits or phases of body length growth have been studied thoroughly and clearly defined. There is no clear conclusion to alveolar process growth. The alveolar process grows via desmal ossification (no preliminary cartilage stage). During vertical facial height development, the maxilla drifts away from the base of the skull independent of the teeth in that material is resorbed from the cranial aspect and built up caudally [2]. Apart from the drift, further skull independent of the teeth in that material is resorbed from the height development, the maxilla drifts away from the base of the ossification (no preliminary cartilage stage). During vertical facial alveolar process growth. The alveolar process grows thoroughly and clearly defined. There is no clear conclusion to development of the children or adolescent patients.

Psychosocial development

Keywords: Dental implants during growth; White and pink aesthetics (WES/PES); Photometric analysis; Ageneses; Traumatic tooth loss; Psychosocial development

Prospective Implant Placement Following Traumatic Loss of Anterior Teeth in a Growing patient and Anticipation of Residual Growth

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Summary

15 years ago, an interdisciplinary concept, covering the controversial topic of implants in growing patients, was developed which aimed at producing early positive functional and aesthetic results in the upper anterior region of adolescents. Following anterior tooth trauma and in cases of agenesis, extensive orthodontic diagnostic and therapeutic pretreatment was first performed according to modifications of the accepted guidelines for adults followed by implant placement anticipating expected jaw growth. The objective is to prevent inactivity atrophy following tooth loss and achieve symmetry to the contralateral tooth once growth has been concluded. The concept encompasses modifications to the prosthetic restoration. 179 implants were placed in the upper anterior regions of patients aged between 12 and 17 years. The results obtained during the growth period were checked every six months and evaluated using standardised photo documentation. To date, the examinations up to conclusion of growth have been carried out, evaluated and published for 67 implants.

The outcome of the photometric analysis indicates that, in comparison to the corresponding teeth during the growth period, compromises in the aesthetics of the emergence profile must be accepted but that, in all cases, once jaw growth has been concluded, the white and pink aesthetics exhibit no significant differences to the corresponding teeth.

Keywords: Dental implants during growth; White and pink aesthetics (WES/PES); Photometric analysis; Ageneses; Traumatic tooth loss; Psychosocial development
adolescents. In addition, the implant position is matched to the growth pattern during growth is completed last [16]. It is heavily influenced by the genetically-determined facial type (long or short). Implants placed before vertical growth has been completed may end up in the maxillary sinus or nasal cavity [8]. A further problem is that growth takes place individually in very different phases influenced by orthodontic treatment and muscle activity (e.g. masseter muscle). Particularly powerful growth episodes are to be anticipated during puberty, i.e. the patient's age is not the sole criteria to be considered when deciding pro or contra implant placement. Intensive planning and interdisciplinary cooperation are required in order to determine the correct moment in time [17,18]. Thus, vertical growth is lower and, if it only develops in breadth, can resemble the position of implant placement in adults.

With adolescents the vertical position is matched to the growth pattern. Following the pubertal growth episode, 3.1 mm vertical growth may still take place and must be anticipated for the implant position. During therapy, a brachiofacial horizontal growth pattern is advantageous compared to a dolichofacial vertical growth pattern. A brachiofacial growth pattern results in formation of a broad, low face. Thus, vertical growth is lower and, if it only develops in breadth, can resemble the position of implant placement in adults.

A dolichofacial growth pattern forms a narrow, high face. In such cases, there is a high risk of vertical malpositioning if the vertical development of the mid-facial section is due to growth of the residual vital teeth and consequent high vertical growth of the alveolar process which is difficult to predictmetrically. Once placed, the implant has no influence on the growth of the alveolar process and retains its position within this region of the jaw. Placing the implant fixes its position permanently without surgical procedures such as segment osteotomy or distraction osteogenesis. The vertical position appears to be the greatest problem when placing implants in adolescents' jaws. Following the pubertal growth episode, a maximum of 7.9 mm infracclusion was observed in cases of early implant placement. The metric predictability of how many millimetres of potential growth the alveolar process exhibits in combination with the skeletal growth of the base of the jaw has yet to be defined.

The largest group of facial types is located between the two types of growth and encompasses horizontal and vertical expansion. This facial type is referred to as the mesiofacial type and applies to 70% of the population.

Prospective positioning of the implant including anticipating the residual growth, takes into account the growth pattern and type. Once growth has been concluded, the emergence profile and prosthetic restoration should correspond to the contralateral tooth. Modifying or remaking the prosthetic restoration during the growth episodes are part of the concept but the position of the implant remains unchanged. Early rehabilitation of adolescent patients is advantageous in that during their development they are provided with a fixed tooth which has a positive effect on their masticatory, speech and personality development.

In order to visualise prospective implant placement including anticipating growth, a patient from our practice will be described. Treatment commenced on 17-08-2010 at the age of 11 years, 7 months. Tentative conclusion of therapy: 09-03-2020 at the age of 21 years, 2 months.

On 17-08-2011 a boy aged 11 years, 7 months presented in our practice with trauma of tooth [6]. The clinical and radiological diagnoses indicated pulpal aperta of both pulp horns and a suspected palatal longitudinal fracture. Conservative treatment involving direct pulp capping followed by endodontic procedures was performed in an attempt to retain the tooth and restore its aesthetics as well as masticatory functioning (Figures 1 and 2).

Following recurrent suppuration, on 20-08-2012 the longitudinally fractured tooth [6] was extracted at the age of 13 years, 7 months. To
prevent atrophy due to inactivity, socket preservation was carried out using Bio-Oss Collagen and autologous bone particles. A double-wing, resin-bonded bridge was then placed temporarily.

Once the orthodontic pre-treatment, diagnostic measures for anticipated growth and growth types had been completed, upon commencement of the lateral atrophy on 25-10-2013 the implant was placed at the age of 14 years, 9 months. Beginning lateral atrophy is the strongest indication that inactivity atrophy is setting in and the latest moment in time for implant placement once the canines have reached their definitive positions. It is an advantage if the pubertal growth episode has already been completed (Figures 3-5).

After an 8-week healing period on 20-12-2013 the implants were recovered and a modifiable crown placed at the age of 14 years, 11 months.

Due to the planned implant position, the marginal region of the crown was designed asymmetrically too short in comparison to the contralateral tooth and exhibited a considerable excess of hard and soft tissue. For the continued growth of the alveolar process caused by the vital teeth growing toward the occlusal plane, this potential growth was taken into account when planning the emergence profile of the mesiofacial growth pattern of the mid-face (Figures 6 and 7).

A growth episode typical for boys occurred from April to August 2014 between the ages of 16 and 17 years. The patient's body grew 24 cm in length during this period and the prosthetic restoration was twice adapted to the growth episode and continued to exhibit excess hard and soft tissue around the marginal emergence profile (Figures 8-11). Simultaneously, due to the clockwise growth of the natural teeth toward the palatal aspect, the implant appeared to have been repositioned slightly toward the vestibular aspect.

Up to the age of 20 years the prosthetic restoration was not modified. At the age of 19 years, 2 months, the incisal edge of the crown appeared slightly too short (Figure 12). The patient's body had grown 2 cm from 183 cm to 185 cm and the prosthetic restoration was replaced with a new occlusal screw-retained crown. The excess tissue was used to form the emergence profile symmetrically to the contralateral tooth (Figures 13-16).

The check-up at age 21 years shows the perfectly stable outcome for tooth [6] (Figures 17 and 18).

Figures 19-25 shows clearly the growth over the past years. During placement, the first, third and definitive crowns were secured intraorally in order to visualise the growth. The changes due to growth can be seen clearly in the marginal and incisal regions. For clarification, the crowns were placed on the first and last model, photographed and evaluated metrically. The predicted growth is also clearly visible here.

**Discussion and Conclusion**

In case of agenesis or upper anterior tooth loss in children and adolescents, conventional restorations exhibit serious drawbacks and sometimes have negative consequences for the dental and psychosocial development of these young patients [1,16,20-22]. One of the serious problems is bone loss in the affected region which often can only be

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**Figure 1 & 2:** Conservative treatment involving direct pulp capping followed by endodontic procedures was performed in an attempt to retain the tooth and restore its aesthetics as well as masticatory functioning.

**Figure 3-5:** An advantage if the pubertal growth episode has already been completed.
corrected using time-consuming and risky augmentation techniques [23,24]. The outcome is often unsatisfactory as loss of hard tissue causes atrophy of the soft tissue. This often leads to loss of attachment on the adjacent tooth which is difficult or impossible to reconstruct. Although early implant placement conserves the bone, considerable risks are involved as the implants do not follow the complex three-dimensional development of the jaw and alveolar process [6,12]. This may cause considerable disadvantages for the functioning and aesthetics. In their 4-year retrospective study Bernard JP et al. [9] monitored infraclusion of implant-borne anterior crowns. The survival rate of implants placed before the age of 13 was approx. 20% higher than in older patients [5,2]. The complications were increased by the fact that the growth of individual patients is difficult to estimate—the teeth may drift mesially by up to 5 mm 9. Owing to these risks, it is now recommended that implants not be placed prior to the age of 19 years [10,6,7]. In contrast, the morphological and psychosocial aspects of early implant placement are considered positive. The literature increasingly includes reports about implant-borne restorations placed during the growth phase. This applies particularly to patients with oligodontia or anodontia in connection with ectodermal dysplasia or other rare clinical pictures with comparable problems [25-33]. But the data available remains insufficient. According to an analysis by Yap AK, et al. [34] covering 12 studies with 471 patients (one cross-sectional study (n=52), three prospective case studies (n=197), six retrospective case studies (n=104) and two mixed studies (n=118)) for those patients with ectodermal dysplasia the survival rate is between 88.5% and 97.6% (3 studies involving 71 patients) and in case of agenesis with other causes 90% and 100% (178 patients involved in 5 studies). In one of the studies (n=13) no difference in the survival rate was determined between the 3 age groups (up to 11 years, 11-18 years, over 18 years). Heuberer S, et al. [33] placed 71 implants in 18 oligodontia patients aged 12.5 years on average. They established a survival rate of 89% at an average period in situ of 11 years. In an international Delphi study involving 11 internationally experienced teams Klineberg I, et al. [34-36] attempted to establish a consensus for the rehabilitation of children with ectodermal dysplasia. The implant treatment was to be
Figure 12: At the age of 19 years, 2 months, the incisal edge of the crown appeared slightly too short.

Figure 13-16: The excess tissue was used to form the emergence profile symmetrically to the contralateral tooth.

Figure 17-19: The check-up at age 21 years shows the perfectly stable outcome for tooth 21.
carried out according to ethical aspects in the children’s best interests as described in the “United Nations Convention on the Rights of the Child” by specially trained and experienced dentists drawn from a multidisciplinary group encompassing the specialist fields of pedodontics, orthodontics, prosthetics and oral surgery. No consensus was agreed upon for the optimum age of patients for implant measures.

The time at which the implant is placed depends on the patient’s growth whereby body growth and condition of the dentition play important roles. Decisive is that the specific patient is observed-generalisation and defining a certain age for patients makes no sense. The therapy depends on the degree of prerequisites for therapy, the time at which the tooth was lost and the outcome of an interdisciplinary analysis of the growth.

In departure from the accepted guidelines for the anterior region [19,37], implants placed during growth must be positioned vertically so as to allow for anticipated growth of the jaw. The anticipated rotation must also be taken into account along the vestibulo-oral axis. Analysis of growth becomes easier and more reliable as age increases. In case of early implant placement, normally only the augmentation procedures described are required. Examining the parents and siblings as well as long-term observation of the specific patient is particularly helpful in determining the position. Following implant placement and until jaw growth is concluded, crowns are fitted which are clinically too short around the margins and the compromised aesthetics accepted. If necessary, during the growth phase the crowns may have to be adapted to the changing conditions several times. In our experience, a favourable moment for placing incisal implants is once the upper canines have been set-up completely.

Prospective implant placement in growing jaws appears to be a possible key to equivalent procedures for adolescent patients with the same indication as for adults. The clinical experience gained with 179 implants placed for this indication is very promising and showed that, even following loss of several incisors, using this procedure the alveolar process can be maintained and long-term favourable aesthetics achieved. It is decisive to make use of all diagnostic, interdisciplinary planning methods and, finally, customised targeted therapy. The implant should be placed as late as possible yet as early as necessary. In this respect, recommendation number 9 of guideline S3 with the AWMF registration number: 083-024 (as of 2016/ valid until December 2021) should be applied analogous to the procedure for traumatic loss of anterior teeth to implant-borne restorations for multiple tooth agenesis and syndromes.

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