Orthodontic Considerations in Restorative Management of Hypodontia Patients With Endosseous Implants

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The use of implant-supported restorations in patients with hypodontia remains challenging and requires a multistage treatment that begins in late mixed dentition and continues into late adolescence. The aim of this article is to review the role of orthodontics in endosseous implant rehabilitation of patients with hypodontia. The MEDLINE, Web of Science, Scopus, Cochrane databases, and necessary scientific textbooks were searched for relevant studies and reviews, and as far as possible, they were only included if they had been cited at least once in the literature. Dental implants are susceptible to overloading as the periodontal ligament is absent and the proprioceptive nerve endings are either lacking or very limited. Patients with hypodontia may present with skeletal features such as short and retrognathic maxilla, prognathic mandible, and shorter lower anterior facial height, and they sometimes need orthognathic correction as part of their overall treatment. Dental problems vary and include bimaxillary retroclination of incisors, spacing, centerline discrepancies, microdontia, hypoplastic enamels, ankylosis of the retained primary teeth, overeruptions, and volume deficiencies of alveolar ridges. The challenges mentioned, as well as bone volume deficiencies, compromise the successful placement of implants. Orthodontic strategies and techniques, such as uprighting mechanics, extrusion/intrusion, delayed space opening, and orthodontic implant site-switching, can be used to create, preserve, or augment the implant site. After orthodontic site development, the final planned position of the teeth should be maintained with a rigid bonded retainer; overlooking this stage may compromise the implant site and require orthodontic retreatment.

Key Words: hypodontia, craniofacial growth, implant-supported restorations, orthodontics, implantology

INTRODUCTION

Endosseous implants (Els) were introduced more than 40 years ago,1,2 and their use in the dental profession has grown exponentially ever since. Els have become the standard of care, providing predictable and reliable treatment alternatives for rehabilitation of patients with edentulous or partially dentate dentitions and those who have congenitally absent teeth.3−9 Despite the high success rate, implant failure still happens, and therefore, extensive research is targeted to identify the contributing causes.10−15 Different shapes and sizes of Els are available. The width of an implant is usually 3.75 mm, corresponding to a platform width of 4 mm. Implants can have a tapered or parallel shape, though the tapered shape is the most frequently used systems. The advantage of the tapered-shape implants is their ability for self-tapping, which is useful for softer bones or immediate loading. Implant dimensions range from 3 to 8 mm in diameter and 7 to 21 mm in length.

The current trends in dental implantology favor less patient comfort and shorter treatment times. Short and wide-diameter implants are associated with faster treatment and less morbidity, eliminating the need for vertical bone augmentation16 or sinus lifting procedures.17 Regrettably, the evidence-based practice is mainly available for the major implant brands.18 Different dental implant systems have been presented in the market, such as
temporary or provisional implants, flapless systems, immediate, immediate-delayed, and delayed implant systems. Flapless procedures are popular as they have been associated with less morbidity. According to recent 18-month to 3-year trials, implants successfully integrate using the flapless approach with immediate loading, similar to conventional protocols.\(^{19,20}\) To date, there is not enough evidence to determine the possible advantages or disadvantages of specific systems or regimens.\(^{21,22}\) Similarly, there is not sufficient evidence for or against performing augmentation procedures for immediate implants placed in fresh extraction sockets, or whether any of augmentation techniques is superior to others.\(^{21–23}\)

Implant-supported restorations have become an increasingly accepted alternative for rehabilitation of dentition, but providing EIs for patients with hypodontia (PH) is not always clear-cut. Various factors should be evaluated before establishing the definitive treatment plan, and the objective of this article is to review the role of orthodontics in EI rehabilitation of PH.

### Literature Search Method

As the material for this review was diverse and heterogeneous, it was not possible to perform a systematic review. Therefore, the MEDLINE, Web of Science, Scopus, and Cochrane databases, as well as necessary scientific textbooks, were searched for the relevant material, and as far as possible, studies and reviews were only included if they had been cited at least once in the literature.

### Epidemiology and Terminology

Edentulous spaces, whether because of pathology or tooth agenesis, are common. The prevalence of hypodontia in permanent teeth, excluding third molars, ranges from 1.6% to 9.6%.\(^{24}\) The term “hypodontia” is generally used to describe the absence of 1 to 6 teeth, excluding third molars.\(^{24}\) However, most (80%) PH lack only 1 or 2 teeth,\(^{25}\) mostly permanent second premolars and upper lateral incisors.\(^{26}\) The severe form of hypodontia, oligodontia, refers to the absence of more than 6 teeth, excluding third molars, and anodontia refers to the complete developmental absence of primary and/or secondary dentitions.\(^{24}\) Nearly, 1% (0.08%–1.1%) of the population has oligodontia.\(^{27–31}\)

### Associated Medical Problems

Few medical conditions can potentially complicate the use of dental implants,\(^{32}\) such as uncontrolled diabetes mellitus, bleeding disorders, a weakened immune system, cognitive problems, and an acquired (ie, radiotherapy) or congenital bone disease.\(^{32}\) Although it is not a medical condition, patients should be able to open their mouth wide enough at the implant site (≥35 mm) to give the clinician enough working space for drilling and placing the implant within the bone.

The severe form of nonsyndromic hypodontia has been associated with the signs or symptoms of ectodermally derived diseases (ie, impaired structure or function of sweat glands, low salivary secretion, deficient hair or nails). Similarly, hypodontia, and particularly the severe form of it, has been related to more than 120 different syndromes, most often with X-linked ectodermal dysplasia and, to a lesser extent, with the autosomal recessive and dominant forms of hypohidrotic ectodermal dysplasia.\(^{31,33}\) Syndromic hypodontia refers to tooth agenesis in patients with an underlying recognizable clinical syndrome, such as Down, Ehlers-Danlos (Type VII), Rieger (Type I), and Witkop syndrome.\(^{34}\) Therefore, potential medical conditions should be excluded, and appropriate medical advice should be sought before drawing up a treatment plan (Figures 1 and 2).

### Dental and Skeletal Characteristics of PH

Tooth agenesis has been associated with certain dental\(^{35–44}\) (Tables 1 and 2; Figure 3) and skeletal features\(^{45–52}\) (Table 2). These features become more noticeable in severe forms of hypodontia. Evaluation of patients with oligodontia\(^{31}\) revealed the following features: maxillomandibular retrognathism, anterior rotation of the mandible, large inferior extensions of the maxillary sinus, receding midface, shorter anterior face height, increased nasolabial angle, deep labiomental fold, and decreased vertical and transversal dimensions of the alveolar process. Further, patients with multiple missing teeth have an increased freeway space that has been attributed to the lack of posterior support.\(^{53}\)
In addition, severe hypodontia has been associated with deep overbite, disturbances of eruption, and microdontia. These features can affect the interdisciplinary management of PH, making the restorative interventions in the edentulous area very challenging. Therefore, early orthodontic management of some of these problems (e.g., deep overbite) has been recommended.

**GROWTH CONSIDERATIONS**

The downward and forward growth of the facial skeleton is a well-known fact (Figure 4). In the maxilla, bone is resorbed from the floor of the maxillary antrum and deposited in the palatal vault, translating the palate in a downward direction. Because there is no periodontal ligament, EIs behave like the ankylosed teeth. This, whether caused by EIs or submerged teeth, exercises an inhibitory and detrimental effect on the eruption of adjacent teeth (i.e., creates a posterior lateral open bite) (Figure 3) or, at least, generates some gingival level discrepancy. Animal and human studies showed that the early use of implants in a growing child led to submergence or positional changes of implants. However, the horizontal and vertical growth of the mandible continues through adolescence and early adulthood. With a Class III tendency and further horizontal growth of the mandible there may be a need for replacing implants or changing the abutments in the future. (Figure 5). Agenesis of the mandibular left second premolar is shown. The size of the second retained primary mandibular molar is larger (9.5 mm) than that of the adjacent premolar (7.5–8 mm).
Further, because of the maxillomandibular transverse growth, early implant placement in the posterior maxilla and, to a lesser extent, in the posterior mandible can lead to transverse displacement of the implants. In addition, the anterior or posterior rotational growth changes of the facial skeleton may alter the inclination of dental implants. To reduce the psychological distress in growing patients and increase their self-esteem and social acceptance, early placement of EIs may take place in extreme forms of hypodontia, such as hypohidrotic ectodermal dysplasia, severe oligodontia, or anodontia. This may take place in children as young as 3 years old to provide support for overdentures or bridge restorations, usually by placing 2 or more EIs between the mandibular canines. However, the overall growth of the face may dictate placing provisional implants or revising the abutments and restorations periodically. The positional growth changes of implants and abutments must be addressed properly to prevent overloading and possible implant failure. In general, the recommendation is to delay placing EIs until most growth is complete. This tends to be earlier in females (17 years) than males (18–21 years), and can be assessed by serial lateral cephalometric evaluations. To conclude, there are also reports of submergence or positional changes of implants due to late adult growth, and consequently, long-term evaluation of occlusion and follow-up of patients with implant-supported restorations are recommended.

### Multistage Orthodontic Treatment and Retained Primary Teeth

The primary objective of orthodontic treatment in PH is to minimize and consolidate edentulous spaces. If implant-supported restorations are planned, the objective is to use the minimum required number of EIs without compromising the function, facial profile, and dental esthetics. The interdisciplinary management of PH involves different stages, and orthodontics can correct some alveolar bone deficiencies and achieve root parallelism adjacent to the implant site. Patients with severe forms of hypodontia and fully edentulous arches occasionally benefit from an implant-supported overdenture during the primary dentition. This is to provide function, prevent distortion of the occlusal plane, eliminate overeruption of opposing dentition, and improve the child's self-esteem and social acceptance.

For most PH, orthodontic management starts in the mixed dentition, usually after radiographic screening around the age of 8 years, and assessment of records. Radiographic screening with a panoramic radiograph at age 8 years identified 65% and 85% of patients with permanent teeth, respectively. This first stage of treatment may coincide with some restorative management of microdontia, which is often associated with hypodontia. Interceptive measures, such as simple orthodontic space redistribution, ease the guided eruption of teeth. The persistence of the primary teeth is the result of congenital absence of successors or the impaction of successor teeth. Mandibular primary second molars and maxillary primary canines are the most cited. At this stage, detecting any infraocclusion of retained primary teeth is imperative to prevent any future vertical bone deficiency.

### Table 1

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<th>Feature</th>
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<tr>
<td>Small teeth (microdontia)</td>
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<td>Infraocclusion of primary molars</td>
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<tr>
<td>Spacing in dental arches, malpositioned teeth, centerline discrepancies, overeruption of teeth</td>
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<tr>
<td>Uneven gingival margins</td>
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<td>Enamel hypoplasia</td>
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<td>Taurodontism</td>
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<td>Delayed dental development</td>
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### Table 2

<table>
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<th>Skeletal and Dental Features</th>
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<td>Smaller cranial base length and angle</td>
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<tr>
<td>More retrognathic and shorter maxilla</td>
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<td>More prognathic mandible</td>
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<td>Smaller mandibular plane and sagittal jaw relationship angles</td>
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<td>Straighter facial convexity</td>
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<td>Shorter lower anterior facial height</td>
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<td>Bimaxillary retroclination</td>
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<td>Greater retroclination of maxillary and mandibular incisors</td>
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<td>Larger interincisal angle</td>
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sion can be caused by ankylosis, the most likely reason, or tipping of adjacent permanent teeth, leading to impaction of the primary tooth.\textsuperscript{86} A bitewing radiograph shows the bone level around the suspected ankylosed tooth, and a flat bone level is usually a good sign, but vertical bone defects most likely indicate an ankylosed tooth.\textsuperscript{87} This is imperative to keep the length of this early orthodontic treatment to a minimum, avoiding losing the patient’s compliance.

The definitive restorative occlusal objectives are reviewed and established during the late mixed dentition. The final position of the teeth and the future implant sites are established during orthodontic treatment in the permanent dentition. This is followed by placing a rigid bonded retainer or a resin bonded bridge to maintain the teeth and their roots in the correct position. If implant-supported restorations are the treatment of choice, all retained primary teeth without successors should be preserved to maintain the buccolingual width of the alveolar ridge. A primary molar is usually much wider than the successive premolar.\textsuperscript{87} This discrepancy in size requires some mesiodistal tooth reduction and restorative buildup of the retained primary molar (Figure 5).\textsuperscript{70,88–90} This lessens the occlusal load on the primary tooth; increases the long-term survival, thereby preparing the implant site for a properly sized implant-supported restoration; and preserves the buccolingual width of the alveolar ridge.\textsuperscript{70}

Limited evidence is available for timing of primary tooth extraction and placement of implant, and recommendations are based mainly on clinical experience.\textsuperscript{74} The retained primary molars are not very good at maintaining the vertical height of the alveolar ridge, particularly if infraoccluded, which leads to creation of vertical bone deficiencies; thus, vertical bone augmentation of the implant site may be needed in the future (Figure 3). The ankylosed primary molars either need interproximal reduction and restoration of the occlusal surface to maintain the occlusion or should be extracted where severe infraocclusion prevails. There is limited evidence on the long-term survival of primary teeth,\textsuperscript{74,91} and the longest life span is reported for the mandibular deciduous canines followed by maxillary canines.\textsuperscript{92} Retention of primary mandibular second molars beyond the age of 20 usually conveys a good long-term survival.\textsuperscript{86} Some aspects of treatment involving placement of Els or orthognathic surgery should be delayed until most of the maxillomandibular growth is complete, and therefore, preserving primary retained teeth without successors, at least until the late teens, is advisable.\textsuperscript{86}

**BIOLOGICAL CONSIDERATIONS**

There are distinct differences between Els and human teeth; for example, Els have no, or a very limited, propioceptive nerve ending to protect them against excessive occlusal forces and overloading. The direct relationship between overloading and implant failure has been debated,\textsuperscript{93} but the consensus is that implant overloading during function increases the risk of implant failure.\textsuperscript{94} An increase in occlusal loading often leads to hypermobility of teeth and periodontal ligament widening, a protective mechanism that is present in all permanent teeth. Nonetheless, Els have a very limited capacity to displace axially (3–5 μm).\textsuperscript{95} Because of the nonexistent periodontal ligament and the absence of proprioceptive protective mechanisms, Els are more vulnerable to occlusal overloading and failure.\textsuperscript{95} Therefore, it is imperative to avoid placing any form of occlusal overload or laterally inclined forces on the implant.\textsuperscript{95} The occlusal loads should be directed down the long axis of implants.\textsuperscript{96} The Els are much narrower (3.75 mm) than the roots of teeth they replace, and forces that are not in line with the long axis of the implant result in greater lateral forces being delivered to implant compared with that of replacing teeth.

Light infraocclusions\textsuperscript{93} cusp-to-fossa occlusal relationships,\textsuperscript{96} as well as light or no occlusal contacts in eccentric excursions should be planned for implant-supported restorations, so far as practicable, to reduce the occlusal overloading and laterally inclined forces. An 8-μm clearance on firm clench and light passive occlusal contacts between implant prosthesis and opposing teeth have been recommended.\textsuperscript{93} Placing implants with an oversized occlusal table can lead to cantilevers, inclined occlusal forces, overloading, premature failure of abutments, and eventually implant failures.\textsuperscript{94,96} An example is a patient with a missing mandibular premolar, where the mesiodistal size of the retained primary tooth is larger than the successive premolar (Figure 3).\textsuperscript{70} This long edentulous space should be shortened to the size of a premolar tooth to avoid having an oversized occlusal table.
ORTHODONTIC IMPLANT SITE DEVELOPMENT AND Bone Volume Deficiencies

The adequate mesiodistal, buccolingual, and vertical spaces for an EI should be planned ahead of placement. Providing space for the implant and prosthetic crown are equally important, and as a rule, for an implant 4 mm in diameter, approximately 2 mm of bone support is needed on either side of the implant.97 This translates to a minimum of 8 mm of bone thickness mesiodistally or buccolingually. However, for esthetic results and proper appearance of the interproximal papilla, the recommendations go beyond the 2 mm bone thickness in the mesiodistal direction, that is, an interimplant and implant-tooth distances of 3 and 3–4 mm, respectively.98,99 A minimum of 8 mm vertical space is required to fabricate and design a prosthetic crown (from the crest of alveolar bone to the occlusal surface of the opposing teeth). Violating these simple rules can lead to inadequate blood supply to the thin bone plate that surrounds implant and may result in bone resorption and bone dehiscences. This is particularly important in the maxillary anterior region, where immediate or delayed loading can be the treatment of choice after extraction of periodontally compromised or traumatized teeth. The so-called “bundle bone” is the portion of alveolar bone surrounding teeth, and into which the collagen fibers of the periodontal ligament are embedded.100 The bundle bone is functionally dependent on blood supply from the periodontal ligament and periosteum. The maxillary anterior buccal crestal bone thickness can be very thin and deficient in vertical and buccolingual dimensions, much less than 2 mm.101,102 In fact, similar to findings in cadaver103 and clinical104 studies, a recent cone-beam study101 revealed that facial bone thickness ≥2 mm at levels 1, 2, 3, 4, and 5 mm from the bone crest was present in 0%, 1.5%, 2.0%, 3.0%, and 2.5% of patients, respectively. After removal of teeth, blood supply to this predominantly thin facial bone overlying maxillary anterior teeth can be disrupted, leading to detrimental bone loss or soft-tissue recession.101,102,105,106 Therefore, atraumatic procedures, use of alternative implant sites with adequate bone volume, and delayed placement of implants are recommended until enough bone volume is generated at the implant site by performing bone grafting, socket preservation techniques, or orthodontic bone generation (Figures 6 and 7).107–110

When the teeth are extracted or in adult PH, opposing or adjacent teeth may overerupt or drift into the edentulous space and compromise the space needed for implant-supported restoration (Figures 8 and 9). Orthodontic therapy is often required to create enough space for the implant and the implant-supported restoration. The space creation involves space opening in mesiodistal dimension, or in vertical dimension with overerupted opposing teeth. Correcting teeth that are tilted or that have drifted into the edentulous space usually involves some form of uprighting mechanics (Figure 8). Mini-implants and EIs111 may be used as temporary or absolute source of anchorage to facilitate tooth movement (Figure 8). The mini-implants, or the so-called “temporary anchorage devices,” are usually 1.2 mm in diameter and 6–8 mm long, small enough to be inserted between the roots of teeth and used for molar intrusion. The overeruption of opposing teeth can be successfully corrected using mini-implant–assisted intrusive mechanics (Figure 9).111,112 The accelerated intrusion of overerupted molars can be achieved by combining the use of mini-implants and selective alveolar corticotomies113 or osteotomies.114,115 When orthodontic implant site development is completed, a rigid fixed retainer is often required to stabilize and retain the teeth, restraining any root reapproximation or unwanted tooth movement.

ORTHODONTIC STRATEGIES TO AUGMENT OR PRESERVE THE IMPANT SITE

A minimum bone volume is required for successful placement of EIs. There are varieties of surgical techniques to augment the alveolar bone but discussing these techniques is beyond the scopes of this article. Briefly, these include, but are not limited to, bone grafting procedures, ridge expansion techniques, osteodistraction, and sinus lifting procedures. Some orthodontic strategies to augment or preserve the implant site are briefly discussed in the following.

Orthodontic extrusion

The orthodontic extrusion of nonrestorable or periodontally compromised teeth increases the hard- and soft-tissue volume in the future implant site116–119 and may eliminate the vertical bone volume deficiencies. Alveolar ridge augmentation techniques are more predictable in restoring the width of an alveolar
ridge than its height; nonetheless, orthodontic extrusion is one of the most reliable means of gaining vertical bone augmentation. This is particularly true in the maxillary anterior region, where vertical bone augmentation is difficult. Good plaque control, the existence of at least one-third to one-fourth of the apical attachment, and a sufficient stabilization period are necessary for a successful forced eruption. The orthodontic extrusion is done at a rate of 1 mm per week, and a stabilization period of 1 month for each millimeter extruded has been recommended. When a periodontally compromised tooth is extruded, torquing and tipping of the tooth toward an angular bone defect increase the alveolar bone volume in the future implant site. With this strategy, some improvement of the interproximal papillary height can be expected.

**Delayed orthodontic space opening**

Reductions in the buccolingual and vertical dimensions of the alveolar ridge occur after extractions or in patients with congenitally missing teeth. In one study, after extraction of primary mandibular second molars, the ridge narrowed by 25% during the first 4 years, and after 7 years, it narrowed by an overall of 30%. This ridge defect that is mainly in the buccal side requires a bone graft or necessitates more lingual or palatal implant placement. The orthodontic space opening has been associated with decreases in bone width in the newly opened sites, though, changes 2 years after finishing the space opening were very minimal. This bone defect may be seen in such areas as the missing maxillary lateral incisor or mandibular premolars. The limited available evidence suggests that, to avoid the surgical ridge augmentation at the site of missing maxillary lateral incisors, the distalization of the canine should be postponed until after the age of 13 years or near the end of skeletal growth (Figure 10); however, this has been disputed.

**Figure 6.** A thin maxillary buccal cortical bone (a,b) (arrows) is a common occurrence and associated with a detrimental bone loss after placing an implant. A recent study revealed that the crestal labial soft tissue thickness and implant’s labial bone thickness were highly associated in the anterior maxillary region. If immediate loading is the treatment of choice, atraumatic extractions and implant site preparations (c) (eg, piezoelectric systems), as well as placement of implants more palatally (d), help avoid complications.
Orthodontic implant site-switching technique

The orthodontic site-switching technique involves moving the adjacent teeth into the bone-deficient edentulous area, closing the edentulous space, and creating an implant site adjacent to the original edentulous area. This newly generated ridge often has adequate bone volume, eliminating further bone grafting (Figure 11). Therefore, by using the adjacent tooth as a stimulus for alveolar site development, the need for bone graft may be eliminated. This technique is valuable for generating enough bone volume in the maxillary and mandibular lateral incisor or premolar regions, common sites for congenital tooth agenesis. For instance, the mesialization of the second premolar into the narrowed and deficient site of a missing first premolar (or vice versa) leaves behind an alveolar ridge with an adequate bone volume, eliminating bone grafting before implant placement.

Replacing congenitally missing teeth often involves some orthodontic space opening or space redistribution during adolescence. Due to continued facial growth and tooth eruption, several years may elapse between the completion of treatment and the provision of implant therapy. Unless a rigid bonded retainer or a resin bonded bridge is provided, positional changes of the teeth adjacent to edentulous spaces are common. The other potential problem is overeruption of unopposed teeth into the edentulous space, which compromises the future prosthetic treatment. Positional changes should be prevented, such as root reapproximation of teeth adjacent to the edentulous area, tilting of adjacent crowns into edentulous space, and overeruption of unopposed molars. A study of the post-retention root position of maxillary central incisors and canines revealed that 11% of patients experienced a relapse that was significant enough to prevent implant placement in

Orthodontic Retention Stage

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These positional changes compromise or prevent the future implant placement, requiring orthodontic retreatment to facilitate implant placement. Apparently, removable retainers are not very efficient in maintaining dimensions of edentulous space; thus, placing a rigid bonded wire or a resin bonded bridge has been recommended. This prevents root approximation during the retention stage or overeruption of unopposed molars after tooth loss.

In summary, this review has described several orthodontic considerations in planning implant-supported restoration for PH. The orthodontic and restorative management of PH, using EIs, requires early diagnosis and multistage orthodontic and restorative treatment. A minimum required bone volume is needed for successful placement of implants and should be considered when formulating the treatment plan. With congenitally missing teeth, adjacent or opposing teeth may tip, drift, or overerupt, leaving edentulous spaces that are not favorable to replacement of missing teeth. Collectively, this affects the space and bone volume required for implant placement or the implant-supported restoration. The staged orthodontic treatment and some orthodontic strategies, such as the orthodontic extrusion, delayed orthodontic space opening, and the orthodontic implant site-switching technique, can preserve or augment the future implant site.

**Abbreviations**

EI: endosseous implant

PH: patients with hypodontia
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