Assessing Treatment Options of Congenitally Missing Lateral Incisors: Shall We Create or Eliminate the Space?

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Abstract: Maxillary lateral agenesis is one of the most seen developmental anomaly in population and requires esthetic and functional treatment from adolescence stage. Successful dental treatment is always the aim for dentists and patients, meaning that a patient's needs are covered in an esthetic and functional way. Several dentists deal with the management of this clinical problem because a multidisciplinary approach can solve the dental demands of patients with dental agenesis. The treatment choices are; no treatment at all and accepting the space, space closure, space opening or redistribution and prosthetic replacement. There is controversy, however, about whether missing lateral incisor spaces should be orthodontically opened or closed using permanent canines to replace the missing teeth. This review considers the possible options: space maintenance and replacement of the missing tooth with denture, bridge (conventional and adhesive), or implant or orthodontic space closure with canine modification.

Keywords: Maxillary lateral agenesis, canine substitution, space closure, space opening, single tooth implant.

Hypodontia is a developmentally deficiency which involves one or more teeth and may present itself with varying degrees of severity [1]. Mandibular second premolars are the most common missing tooth, followed by maxillary lateral incisors are being the second most common missing tooth with the percentage of approximately 20% [2,3]. It has been found that agenesis of both maxillary lateral incisor is more common than agenesis of only one [4]. Sex differences in prevalence have found to be small with slightly more common in females than in males [5].

A multidisciplinary approach is often needed in the treatment of missing maxillary lateral incisors and there are different management alternatives for treating missing lateral incisors [6]. Treatment alternatives are; no treatment and accepting the space or the close contact of central incisors with canines, or re-shaping canines as laterals [7], to orthodontically closing the space (closing the contact with the neighboring canine) [8], or opening, maintaining or redistributing the space in preparation for its forthcoming prosthetic management [9].

These complex interdisciplinary treatment options' prospective esthetic and functional outcomes should be evaluated in detail within the interdisciplinary team and with the patient as well. Many factors need to be considered when deciding on the prognosis of the treatment outcome, such as posterior occlusal relationship, the position and inclination of canines in the arch, the color and the shape of the canine, the necessity of extractions. The primary criteria for either space closure or space opening are assessing the presence or absence of major occlusion problems [10].

Orthodontic management plays a fundamental role in the treatment team as they play the leading role with the capability to create or redistribute the convenient amount of space [11].

Considering that an ideal management in dentistry is the most conservative approach that minimizes the need for the tooth reduction and the least invasive method for satisfying the patient esthetics and functional requirements; the treatment options for replacing missing lateral incisors may be also classified from the most conservative method to the most invasive method basically as: a canine substitution, a tooth supported restorations or an implant [10].

This review contains a comprehensive evaluation of different treatment options requiring interdisciplinary cooperation of different disciplines for the treatment of missing maxillary lateral incisors.

1. ORTHODONTIC SPACE CLOSURE

Generally, maxillary lateral agenesis is diagnosed at an early stage of childhood. Due to the change over time is inevitable in biologic systems, the most

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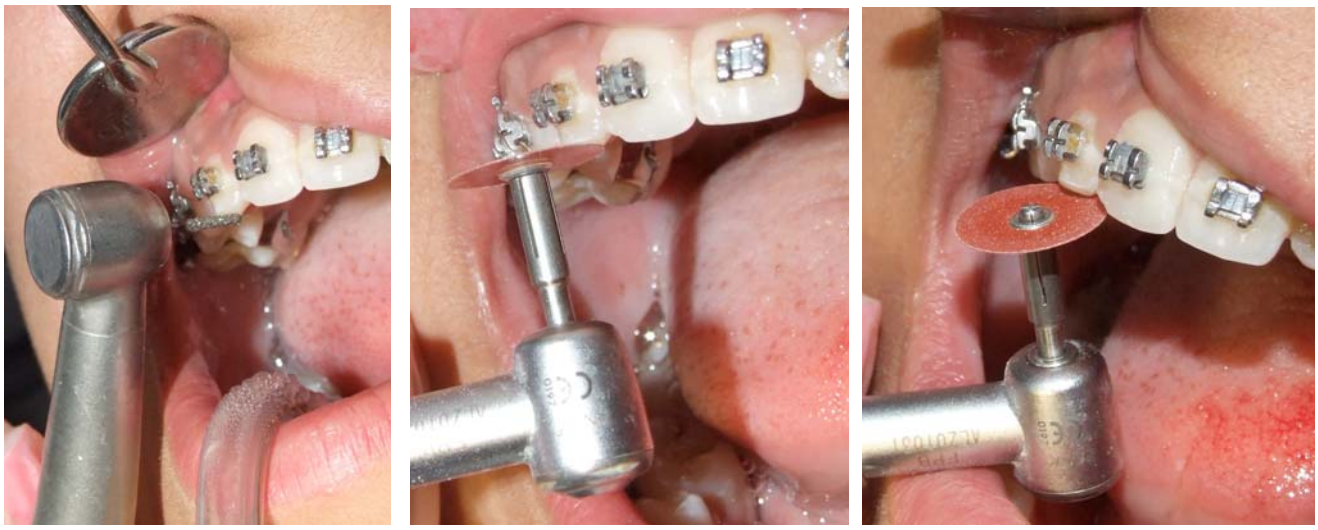
a **b**

Figure 1: a: The intraoral photograph of a 16 years 5 months old patient with missing left lateral incisor. **b**: The intraoral photograph of the same patient after orthodontic and restorative treatments. The left space was closed with fixed orthodontic treatment and gingivectomy operation was performed. Upper right lateral and the left canine were reshaped by resin composite.

important treatment decisions must be linked to the long-term outcome. The results of treatment should preferably be completed when the patients are in their young teens and should be expected to represent a natural dentition over time [12]. It is recommended to delay the use of prosthetic restorations until skeletal growth is completed [13].

Missing maxillary lateral incisors' conventional space closure is a proper and safe procedure that obtains satisfactory functional and esthetic long-term results [8, 12]. This treatment alternative is orthodontically space closure with the maxillary canine substituting and camouflaging the canine to mimic the appearance of a lateral incisor (Figure **1**). The first premolar tooth can also be reshaped as canine for the durability of esthetics. This camouflaging may be accomplished by the orthodontist with tooth reshaping and positioning (Figure **2**); and further progress may be attained by individual tooth bleaching, resin composite buildups, or laminates accomplished by restorative dentistry disciplines [12].

The advantage of space closure using canine substitution is the avoidance of introduction of fixed partial dentures or implants. The prosthetic replacement with fixed partial dentures necessitates intact tooth structure removal and both treatment options are typically more expensively. The parents and the patient should be informed about the damage-benefit relation of the course and limited time span of the invasive operative interventions emphasizing the sacrifice of the sound tooth structures. However, in addressing the esthetic concerns of the patient in very severe situations, this treatment might be the most successful alternative [14]. In addition, while the lateral agenesis patient has gummy smile, the treatment choice should be space closure rather than placing implants [15].



a **b** **c**

Figure 2: a-c: Reshaping of the canine tooth.

However, the difficulty of this option is the differences in natural shade, shape, size and between the lateral incisors and canine [16]. Thus, before selecting canine substitution treatment for replacing missing maxillary lateral incisor, several criteria must be evaluated. First of all, careful consideration of the differences in the morphology between the canine and the lateral incisor is required for this treatment approach, and whether the patient is ultimately appropriate for space closure and the result will be esthetic and acceptable [17]. Another potential disadvantage is that placing the first premolar in the position previously occupied by the canine might result in heavy occlusal forces, because canine-protected occlusion is not possible. Moreover, there is a concern of potential damage to the periodontal health, because the roots of the first premolars are smaller and thinner [8].

Other criteria are malocclusion, the profile of patient, gingival contours and lip level [18, 19]. Before orthodontic treatment, to have good esthetic results, tooth shape, worn incisal edges and contact, the black triangles and gingival margin contours should be evaluated [20]. Patients who has small canines with crowns that match the shade of central incisor tooth are the optimal canine substitution patient. And they should also have Class II dental relationship and no crowding in the mandibular arch. On the other hand, these criteria may not be present all together; other restorative options need to be placed on the anterior area to meet the esthetic demand [21].

Rosa and Zachrisson noted the clinical inferences to the canine substitution treatment protocol [15,22]. To improve the patient's incisor display, it is recommended widening the maxillary central incisors with composite restorations.

Some restorative dentists have been opposed to mesial movement of the maxillary canine into the lateral incisor space as this precludes the potential for developing a canine-protected occlusion because it places the canine in direct opposition to the mandibular lateral incisor [10]. However, Nordquist and McNeill [23] justified the mesial movement of canines into lateral incisor space, which provided many orthodontists with the rationale for space closure. They stated that no difference existed in adequacy of the occlusal function between canine-protected and group

a **b**

c

Figure 3: a: The intraoral photograph of a 13 years old patient with missing right and left lateral incisors. Note that the patient had small canines, mild crowding in the mandibular arch, optimum lip levels. The treatment plan involved canine substitution. **b**: The intraoral photograph of the patient after the fixed orthodontic treatment. **c**: The intraoral photograph of the patient after the resin composite restorative treatment.

function, and no relation with periodontal status existed between the two groups. Their treatment argument was further consolidated by elimination of prosthetic needs, which contribute to plaque accumulation and irritation. Also, several studies have shown that substitution of maxillary canines to mimic lateral incisors enhance the patients' esthetics [24,25].

In some certain cases where the space is eliminated and canine substitution is needed direct resin composite laminates may be applied on tooth surfaces with a composite resin material directly. Absence of necessity for tooth preparation, low cost for patients compared with indirect techniques and other prosthetic restorative approaches, reversibility of treatment and no need for an additional adhesive cementing system are the main advantages of this technique [26,27]. Besides, intraoral polishing of direct laminate veneers is also easy and any cracks or fractures on the restoration may be repaired intraorally [28] (Figure **3**). However, it should also be kept in mind that low resistance to wear, discoloration and fracture propagation are the main disadvantages of the technique [26]. This direct technique may also be considered as a provisional restorative option until the patients' definitive indirect restoration stage when the growth is complete.

If direct resin composite restorations fail to meet the esthetic needs of the patients and/or the indication of direct resin composite restorations are restricted by the existing intraoral condition, other indirect restorative treatment options may be taken into account. It is of clinical importance to be aware of the fact that over the last two decades, the field of esthetic restorations has substantially expanded to satisfy patients' demands with the most conservative options. Traditional treatment approaches like full coverage crown would involve the removal of large amounts of sound tooth substances, which has adverse effects on pulp, gingiva, and crown biomechanics as mentioned earlier [29]. Therefore, it is important to preserve as much tooth structure as possible. In fact, compared to traditional full preparation restorations, minimal reduction of tooth structure, good esthetic properties, color stability, and reliable adhesive strength are the major upper hand advantages of laminate veneers [30].

One of the most conservative restorative treatment modalities is the porcelain laminate veneers (PLVs). Since their introduction in 1930, PLVs have been a popular dental treatment modality. Several clinical studies have reported the esthetic performance, biocompatibility, and durability of porcelain laminate veneers over a period of more than 9 years [31,32]. The clinical survival rate of PLVs is high with a range from 18 months to 15 years [33]. However, long chair time, higher cost and use of an adhesive cementing system are the main disadvantages of indirect laminate veneer restorations [34].

2. SPACE OPENING

In cases with Class 1 skeletal relationships, orthodontic space opening treatment is preferred to treatment by space closing for maintenance of posterior occlusion [18]. Color incompatibility between maxillary canines and central incisors is also another factor for the decision for or against space opening [8]. There are several methods to determine the width of space is required for missing lateral replacement. The first one is named the ''golden proportion'', the second one is to use the opposite lateral incisor as reference, the third method is to use Bolton analysis, the fourth and most appraisable guide for considering the ideal replacement space is to conduct a diagnostic wax-up [18].

When treatment plan involve creating a space for missing lateral incisor, there are 2 treatment alternatives: a tooth-supported restoration and a single-tooth implant. Nowadays, tooth supported restorations can be divided into 3 available categories: a resin bonded fixed partial denture (FPD), a cantilevered FPD, or a conventional FPD [21].

2.1. Implant Supported Restorations

Implants are one of the treatment modalities to take place congenitally missing lateral incisors without disturbing the adjacent teeth in orthodontic patients [35]. An interdisciplinary point of view should be preferred during the diagnosis, prognosis, and treatment scheme to hinder several potential problems. However, the major drawbacks of this treatment option are the unpredictable prognosis of dental implant treatment and the ambiguous ability of meeting the esthetic and functional expectations of a young patient with high esthetic demand.

Skeletal maturation level (the age of the patient), the time elapsing between completion of orthodontic treatment and implant insertion/final restoration, and alveolar ridge dimension are the most challenging factors in the final decision of when to place an implant [36]. In addition to these particular problems in young adolescent patients; anterior relationship, the condition

of adjacent teeth, inadequate bone support for the gingival papilla should be taken into consideration [37].

The minimum age of the implant patient is more often a concern for maxillary anterior tooth replacement, especially for congenitally missing lateral incisors in terms of skeletal maturation level [38]. During the developmental stage vertical and anteroposterior growth changes are substantial in this area. The vertical growth of the maxilla exceeds all other dimensions of the growth in this quadrant; therefore premature implant placement can result in the repetitive need to lengthen the transmucosal implant connection which leads to poor implant-to-prosthesis ratios and the potential to load magnification [39]. Brahmin [40] advised that whenever possible, implant placement must be delayed until the 15^{th} years for girls and 18^{th} for boys. If is placed earlier, it will relatively seem to submerge vertically, because the implant can not erupt like the adjacent teeth [41,42]. Additionally, Thilander *et al.* [42] showed that a predetermined chronological age may not be guidance for implant placement. According to the authors [42] During post adolescence, because of a slight continuous eruption of the adjacent teeth, a dental stage, indicating fully erupted permanent teeth and skeletal maturation completed or almost completed, is not sufficient to hinder infraoclusion of the implant-supported restoration. Similarly numerous of studies showed that infraocclusion may occur correspondingly the continuous eruption of adjacent teeth even an implant is placed in adult with skeletal maturation completed or almost completed [43-47]. Importantly, Thilander *et al.* [44] emphasized that the mentioned infraocclusion with minor degree was seen in patients with good inter-incisor stability also. In addition, the osseointegrated fixtures will not be able to be displaced in the transverse and sagittal dimensions during the growing [41,48].

On the other hand, in the literature there are some studies which are advocating implant therapy with high success rate for the rehabilitation of unilaterally or bilaterally congenitally missing lateral incisor [37,49,50].

A prerequisite for ideally placed implant therapy is an alveolar ridge with adequate dimensions. Undeveloped knife-edge shaped alveolar bone caused by tooth absence makes implant placement a further challenge [51]. Generally, the lack of the dental germ suppresses the normal development of the alveolar crest, which leads to a vestibular concavity. In that case, bone regeneration or grafting might be considered [52]. However, Kokich [53] has proposed that if permanent lateral incisor is congenitally absent, after premature extraction of maxillary deciduous lateral incisor, it may be proper to encourage the permanent canine's eruption mesially into the lateral incisor location. By this way, the bone around the canine forms in the lateral incisor position. The canine can then be orthodontically moved into the ideal canine position. According to the authors [53, 54] this modality could produce a place with appropriate dimensions for implant placement without a grafting. Whereas Beyer *et al.* [55] showed increased bone deficiency with the above mentioned therapy while orthodontic treatment completed. Similarly Uribe *et al*. [56] emphasized that although distal movement of canine may develop the alveolar ridge in patients with congenitally missing lateral incisors, the bone width may not be sufficient for ideal placement of implant without grafting. As an alternative, Nissan *et al.* [51] advised to use cancellous block-allograft successfully in these patients.

Another challenge on implant therapy is what's happen during the elapsing years between completion of orthodontic treatment and implant insertion. According to Beyer *et al.* [55] the time of implantation should be close to the end of orthodontic treatment. As opposed to starting orthodontic space closure early, orthodontic space opening before implantation should be started late [55]. Novackova *et al*. [11] stated that the age is not an essential factor in deciding to start orthodontic treatment. According to the authors, it is possible to move canines distally during adolescence and then wait to place implants when facial growth is complete without any problem about bone resorption in the edentulous area [11]. Another problem during elapsing time is what happens to the position of the maxillary canine and the central incisor root (Figure **4**). Dickinson [57] reported that, the central incisor and canine roots reapproximated during retention and prevented implant insertion after successful orthodontic opening of the implant area. However Olsen and Kokich [58] explained that, approximation of the root between the canine and adjacent central incisor during retention did not occur permanently, only 11% of patients showed a remarkable degree of relapse to prevent implant placement. To ensure proper space for implant placement, 6.3 mm of intercoronal space and 5.7 mm of interradicular space are advised between the adjacent central incisor and the canine, another advice is to take periapical radiograph instead of panoramic radiograph to see these measurements.

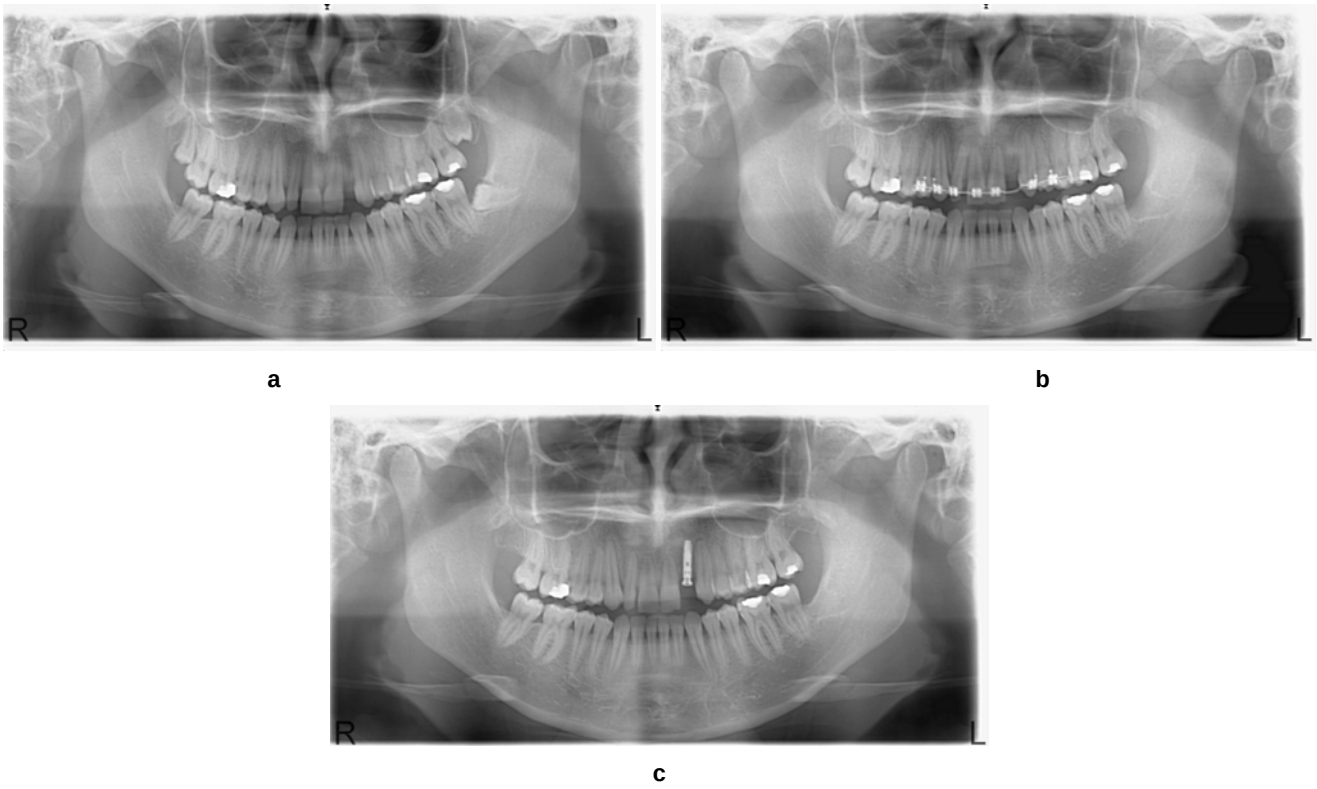


Figure 4: a: The lateral space had been opened for implant placement in a former orthodontic treatment. However, as the skeletal growth had not been completed, implant placement was postponed. Meanwhile, the neighboring teeth closed the space. **b**: The panoramic radiography during the course of orthodontic treatment. **c**: Lateral implant was inserted in the positioned area.

According to Ganz [59] if there is absence of sharpness, definitions, and radiographic artifact that make impossible to examine whether implant could be successfully placed based on the 2D panoramic, computed tomography imaging technology would be beneficial to accurately determine topography of bone and spatial orientation of the adjacent roots in congenitally missing lateral tooth patients.

The edentulous space must be maintained if implant can not be placed until facial growth is complete. For transitional restoration removable prosthesis or fiber reinforced composite bridge fixed prosthesis may be used [60, 61]. Generally, a removable retainer with acrylic teeth and wire stops may be used to retain single tooth spaces (Figure **5**). Carter *et al.* [9] advised that, this type of appliance must be worn full time for a minimum of 6 months, allowing dentoalveolar remodeling in the saddle areas prior to prosthetic rehabilitation, following which it can be worn part time. Although removable retainer with acrylic tooth is an effective way to ensure post-orthodontic retention, the longevity of time between completion of orthodontic treatment and implant insertion may limit the use of this type of retainer [58]. As well, Olsen and Kokich [58] recommended bonded wire or fiber reinforced resin bonded bridge to reduce root approximation instead of removable retainers. Indeed Kokich *et al.* [21] determined that these long-term retainers are excellent for maintenance of final orthodontic position (Figure **6**).

Following the implant placement, periodontal problems with marginal bone loss around the adjacent teeth and bone loss buccally to the implant may also arise because of presence of limited space for implant placement. If the distance between the adjacent teeth and implant is shorter, the reduction of marginal bone level may occur larger [44]. Apart from these particular problems, there are also general risk factors related with implant placement in the anterior maxillary area. Lack of gingival papilla, blue coloring of the labial gingival, abutment exposure due to retraction of the labial gingival might be seen [52]. If the treatment plan must include space opening, it is preferable the space posteriorly and place implants in the premolar area due to the esthetic problems related with the placement of the implants anteriorly [62]. Moreover, if the treatment plan must include space reopening in gummy smile patients, it is also preferable to redistribute the spaces posteriorly and insert implants in the premolar areas [15].

a b

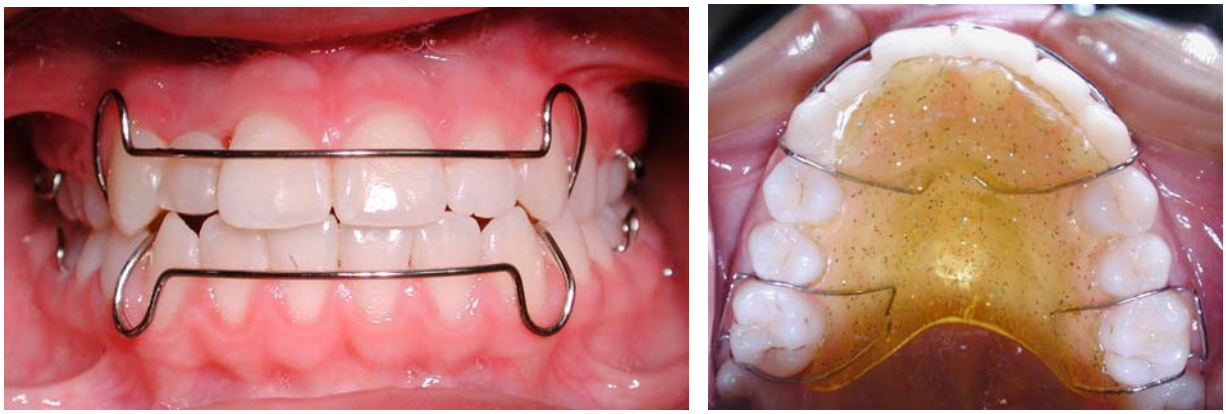


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Figure 5: a: The intraoral photograph of an 11 years old patient with missing right lateral incisor. **b**: The intraoral photograph of the patient after the fixed orthodontic treatment. **c-d**: The intraoral photograph of the patient with removable retainer with acrylic lateral tooth.

a **b**

c

Figure 6: a: The intraoral photograph of a 15 years old patient with missing right and left lateral incisors. The orthodontic treatment plan involved space opening and maintaining the positioned space by fiber reinforced resin composite temporary adhesive retainer until definitive restoration after skeletal growth is complete. **b**: The intraoral photograph of the patient after the fixed orthodontic treatment. **c**: The intraoral photograph of the patient with fiber reinforced resin composite temporary adhesive retainer.

Despite these challenges, implant placement still might be featured treatment option when the conditions get proper. However if implant placement is not considered as a feasible option because of either biological situations or patients undesirability, tooth supported restorations may also be considered as treatment options with satisfactory results. Especially in the patients with gummy smile, it should be avoided implant placement due to interdental papilla recession, blue coloring of labial gingiva and vertical alveolar bone resorption over time [15].

2.2. Tooth Supported Restorations

As stated before, tooth supported restorations are divided into 3 types for congenitally missing lateral tooth patients. These are cantilevered FPDs, resin bonded FPDs, and a conventional full-coverage FPDs [21].

Before starting prosthetic rehabilitation phase, the orthodontic management history should be known, as in general teeth movements required in the management of the patients with hypodontia are endogenously unstable and susceptible to relapse [9]. Resin bonded FPDs were preferred to be the first treatment choice among the tooth supported restorations, because of the advantages of conservation of tooth structure and reversibility [63]. Cakan *et al*. [64] describe the technique esthetically pleasing and rapid to solve the current problem when the implant placement is not possible or not preferred by the patient. Additionally in case of wide span cause of anterior extensive diastemas and missing lateral incisor, modified resin bonded FPD may be an esthetic choice with enhanced natural appearance [65]. While constructing resin bonded FPDs, it's important to pay attention to interocclusal relationship, anterior guidance, and interferences in lateral movements [66]. Contrary to these advantages, It has been shown that the rate of success of resin bonded FPDs widely depends on debonding failure [67-69]. According to Carter *et al.* [9] the relapse that may occur after orthodontic treatment could affect resin-bonded bridges survival. However, Garnet *et al.* [70] showed that there were no statistically significant differences on the resin-bonded bridges' survival for retention period after orthodontic treatment between three to five and six or more months. Similarly, Djemal *et al.* [71] concluded that abutment teeth's orthodontic tooth movement does not cause an additional failure risk for resin-bonded bridges.

Alternatively, the use of 2-unit cantilever fixed partial dentures is considered viable options to replace maxillary lateral incisor using the canine as the abutment teeth [72]. The average lateral incisor is 6.4 mm in width, but patients with congenitally missing teeth often have anterior teeth narrower than typical. Therefore even orthodontic therapy aiming to increase the space between the teeth may be inadequate for a single tooth replacement. As a result, under these conditions, a cantilevered FPD may be the treatment of choice [38]. Although resin bonded FPDs and cantilevered FPDs are conservative tooth supported restorations, the survival rate of resin bonded FPDs is still considerably less than that of conventional fixed partial dentures [67]. Therefore these types of conventional prosthesis are still most preferred alternatives, particularly with advances in full ceramic materials and techniques.

Fixed Partial Dentures (FPD), metal-ceramic or full ceramic, are treatment modality for anterior single tooth restorations. Both techniques require considerable reduction of tooth structure [73]. Although this modality does not utilize tooth preservation, in cases with severe discoloration, full coverage metal-ceramic restoration are required to properly restore teeth. When patients may not want to get implant surgery or can not afford it, combining both the orthodontic and prosthodontic modalities may produce satisfactory results with corrected proclination and lip strain through orthodontic treatment and enhanced smiling trough prosthodontic treatment [74].

In fact, in dental literature there are countless case reports and clinical researches on the treatment modalities of maxillary lateral agenesis however; limited studies are present in the literature comparing these treatment options.

Robertsson and Mohlin [8] reevaluated 50 treated patients (Thirty had received space closure, 20 had space opening with fixed restorative options, without implants) with congenitally missing lateral incisor. The mean time after treatment was 7.1 years (range, 0.5-13.9 years). According to the authors, the space-closure patients were more satisfied with the treatment results than the prosthesis patients; however there was no difference between the 2 groups in prevalence of signs and symptoms of temporamandibular joint dysfunction, and patients with prosthetic replacements had impaired periodontal health depending on accumulation of plaque and gingivitis.

33 treated patients with at least 1 missing maxillary lateral incisor (39 with space closure, and 19 with space reopening and fixed partial dentures) were also

Figure 7: a: The intraoral photograph of a 27 years old adult patient with bilateral missing lateral incisors and without gummy smile. **b**: The intraoral photograph of the patient after the fixed orthodontic treatment with space opening procedure. Because of the low lip level, the gingival margins can not be seen and his smile was wildly. **c**: The intraoral photographs of the patient with implant restorations.

reevaluated by Nordquist and McNeill [23]. The mean post-orthodontic treatment interval was 9 years 8 months. Authors concluded that patients with lateral incisor spaces closed were significantly periodontally healthier than those with prosthetic lateral incisors. Also no difference were found in adequacy of occlusal function between the 2 groups, and no evidence to support that establishing a Class I canine relationship should be the preferred mode of treatment.

Tuverson indicated that the canine shade generally comes closer to that of adjacent teeth than the porcelain crowns shade [75].

In recent studies, a series of photographs of teeth that included subjects with agenesis of the lateral incisors were evaluated by general dentists, orthodontists, other dental specialists, and lay people. Authors tried to analyze how they evaluated the relative attractiveness of these series of photographs [76, 77]. Subjects with different kinds of prosthetic restorations, and canine substitution were included in the photographs. The patients who had no missing teeth were evaluated as controls. According to visual evaluation, photographs of the canines as lateral incisors were ranked as the best of all options by the lay population. However, the orthodontists rated each category significantly different from best to worst: no missing teeth, canines as lateral incisors, resin-bonded bridges, and implants. The lateral incisors with implants were the restoration choice of most of the general dentists and other dental specialists compared with orthodontists.

As a summary, it should be kept in mind that, space closure is a common treatment modality in patients with gummy smile and young patients; while elderly patients may be treated with space opening treatment alternative (Figure **7**).

CONCLUSION

In light of these literature findings, it is important to understand that each patient is unique and deserve a unique treatment plan. There are numerous different options for the treatment of missing maxillary lateral incisors. However as a clinician, it is very important to understand the esthetic and functional needs of a particular patient, eliminate personal opinions on what we believe the most esthetic choice, but rather present the available treatment options.

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