Dental Implant Treatment with Computer-assisted Surgery for Bilateral Agenesis of Maxillary Lateral Incisors: A Case Report

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Received 21 March, 2017/Accepted for publication 4 April, 2017

Abstract

Here, we report a case of dental implant treatment involving computer-assisted surgery for bilateral agenesis of the maxillary lateral incisors. The patient was a 39-year-old woman with the chief complaint of functional and esthetic disturbance due to maxillary and mandibular malocclusion. The treatment plan comprised non-extraction comprehensive orthodontic treatment and prosthodontic treatment for space due to the absence of bilateral maxillary lateral incisors. A preliminary examination revealed that the mesiodistal spaces left by the absent bilateral maxillary lateral incisors were too narrow for implant placement (right, 5.49 mm; left, 5.51 mm). Additional orthodontic treatment increased these spaces to approximately 6 mm, the minimum required for implant placement if risk of damage to the adjacent teeth due to inaccuracies in directionality of drilling is to be avoided. For dental implant treatment with computer-assisted surgery, preoperative planning/simulation was performed using Simplant® ver.12 software and a tooth-supported surgical template fabricated using stereolithography. Two narrow-diameter implants were placed in a two-stage procedure. It was confirmed that there was sufficient distance between the implant fixtures and the roots of the adjacent teeth, together with no exposure of alveolar bone. Following a 4-month non-loading period, second-stage surgery and provisional restoration with a temporary screw-retained implant crown were performed. Cement-retained superstructures made of customized zirconia abutment and a zirconia-bonded ceramic crown were fitted as the final restoration. At 5 years after implant surgery, there were no complications, including inflammation of the peri-implant soft tissue and resorption of peri-implant bone. Computer-assisted implant surgery is useful in avoiding complications in bilateral agenesis of the maxillary lateral incisors when only a narrow mesiodistal space is available for implant placement.

Key words: Dental implant — Maxillary lateral incisor agenesis — Computer-assisted implant surgery — Narrow implant
Introduction

Missing teeth can result from acquired causes such as trauma, caries, periodontal disease, and other infections, or dental agenesis. Dental agenesis is responsible for between 2% and 10% of missing teeth\(^2\). In Japanese people, the incidence of agenesis is highest for the mandibular second premolar, followed by the mandibular lateral incisors, the maxillary second premolar, and the maxillary lateral incisors\(^5\), and bilateral agenesis most commonly affects the maxillary lateral incisors\(^5\). Dental treatment aimed at rectifying functional disorder and esthetic disturbance due to agenesis of the maxillary lateral incisors involves orthodontic and/or prosthetic treatment, and will include a conventional bridge, a removable partial denture, and a dental implant\(^10\).

Dental implant treatment for missing intermediate teeth is well established. Its advantage is that it protects the remaining natural teeth as it does not impair transmission of occlusal force, unlike with conventional prosthetic treatment involving a bridge and removable partial denture. In cases of agenesis, however, it is not always possible to ensure sufficient mesiodistal space for implant placement, as the remaining adjacent teeth may move and tilt into the edentulous area. Furthermore, even if the mesiodistal space is preserved by the presence of a deciduous tooth, there may still be insufficient space for implantation if there is agenesis of a maxillary lateral incisor. This is because the width of the crown of the maxillary lateral incisor in the permanent dentition is only 7.07 ± 0.43 mm, making it the narrowest in the maxilla, although still wider than that in the primary dentition\(^4,10\). Earlier studies have noted that an implant fixture should be 1.5 to 2.0 mm away from adjacent teeth to avoid various complications, including damage to the root and peri-implant bone loss. Therefore, a minimum mesiodistal space of 6 mm is required to insert a narrow implant (diameter 3.0–3.5 mm) in a single-tooth edentulous area\(^8,11,16\). This indicates that dental implant treatment in cases of agenesis of the maxillary lateral incisors is going to be problematic as it carries a high risk of complications such as damage to the root of the adjacent tooth due to inaccuracies in the directionality of drilling\(^9,21\).

Recently, the development of stereolithographic technology has allowed the faithful reproduction of 3-dimensional virtual data. This and the advent of computer-assisted design and manufacturing (CAD/CAM) technology have facilitated computer-assisted implant surgery, which has improved the accuracy of implant placement compared to conventional freehand insertion\(^2,5\).

Here, we report a case of bilateral agenesis of the maxillary lateral incisors with insufficient mesiodistal space for implant insertion. A good outcome was achieved, with pre-implant orthodontic treatment securing approximately 6 mm of mesiodistal space and computer-assisted implant surgery allowing various potential complications to be avoided.

Case

The patient was a 39-year-old woman who presented at the Department of Orthodontics, Tokyo Dental College Chiba Hospital in September 2008 with the chief complaint of functional and esthetic disturbance due to maxillary and mandibular malocclusion. Her systemic medical history contained nothing of note. At the age of 7–8 years, she had undergone deciduous lateral incisor extraction at a local dental clinic, but no prosthetic treatment was performed. On her initial visit to our hospital, spacing in the dentition of the maxillary dental arch due to the absence of bilateral maxillary incisors and crowding of the lower incisors was noted. The molar relationship showed Class I on the left side and Class I with a slight Class II tendency on the right side (Fig. 1). The findings on a panoramic radiograph were all normal, except for agenesis of the maxillary lateral incisors (Fig. 2). Lip protrusion was balanced, however, due to a normal E-line value. As her
L1-Apo value was 5.5 mm, as opposed to a normal value of 3 mm, slight flaring of the lower incisors was revealed by a Rickett’s analysis. Following a comprehensive clinical and database analysis, a treatment plan was developed. This comprised non-extraction; lingual movement of the lower anterior teeth; and an increase in the space left by the absent bilateral maxillary lateral incisors by closure of the median diastema and distal movement of the bilateral canines. It was decided to create sufficient space in the upper left lateral incisors to allow for either a conventional bridge or a dental implant, as the patient had not decided on which option to go for at this point. Orthodontic treatment was commenced at the Department of Orthodontics in January 2009, during the course of which, the patient decided on the dental implant option. At this point, however, it was still not clear as to whether this would be feasible, in which case, a bridge would be the fallback option. By October 2010, space had been secured for placement of an implant by closure of the median diastema and distal movement of the bilateral canines. At this point, the patient visited the Department of Oral and Maxillofacial Implantology for a preliminary examination. Cone-beam computed tomography (CBCT) was used to measure the buccolingual width and mesiodistal spaces in the area of the missing maxillary lateral incisors for assessment of implant placement. The results of buccolingual width measurement revealed that the right side was 6.05 mm and the left side 6.28 mm. On the other hand, mesiodistal space showed 5.49 mm on the right side and 5.51 mm on the left side. Based these results, it was decided that additional orthodontic treatment would be required to make these spaces sufficient for a dental implant. Both these mesiodistal spaces were
less than 6 mm, which is the minimum required for implant placement. Therefore, on our suggestion, the patient agreed to undergo additional orthodontic treatment to increase these spaces. In April 2011, orthodontic treatment transitioned from tooth movement to retention, and further examination was carried out aimed at dental implant treatment (Fig. 3). The second round of CBCT involved a scanning template comprising radiopaque artificial teeth (Fig. 4a). The results revealed that the bilateral buccolingual and mesiodistal spaces were greater than 6 mm (Fig. 4b). For dental implant treatment with computer-assisted surgery, dicom data extracted from the CBCT data were imported into the preoperative planning/simulation software (Simplant® ver.12; Materialise Dental, Leuven, Belgium) and the diameter, length and positioning of the implant fixtures investigated (Fig. 5). Based on these data, a tooth-supported surgical template for computer-assisted implant surgery (Universal-Guide®; Materialise Dental) was fabricated using stereolithography (Fig. 6a).

In July 2011, computer-assisted implant placement surgery was performed in a two-stage procedure. After application of local anesthesia, a mucoperiosteal flap was opened and the tooth-supported surgical template mounted (Fig. 6b). Drilling for implant bed preparation was performed according to the manufacturer’s protocol. A 2-mm diameter twist drill with a guide key inserted into the master tube of the surgical template was used to drill to a depth of 10 mm (Fig. 6c), and a 2.4/2.8-mm-diameter twist step drill was used for the final drilling step in implant fixture placement (Fig. 6d). The surgical template was then removed and the bilateral implant fixtures (NobelActive Internal NP; Nobel Biocare, Gothenburg, Sweden; diameter, 3.5 mm; length, 10 mm) inserted into the created implant beds using a torque wrench. The depth of implant insertion was confirmed under direct-viewing conditions (Fig. 6e). Primary stability was recognized at ≥35 N for both implants. In the two-stage procedure, a cover screw was fitted into both of the implant fixtures and the mucoperiosteal flap sutured to achieve wound closure (Fig. 6f). Figure 7 shows the CBCT images obtained after implant surgery. These revealed that a sufficient distance had been achieved between the implant fixtures and the roots of the adjacent teeth, and that there was no exposure of
alveolar bone. Following a 4-month non-loading period, second-stage surgery and provisional restoration with a temporary screw-retained implant crown was performed in November 2011.

Giving priority to esthetic factors, cement-
retained superstructures were selected for the final restoration; customized zirconia abutments (Nobel Procera Abutment; Nobel Biocare) and zirconia-bonded ceramic crowns were fitted with temporary cementation (HYBOND TEMPORARY CEMENT, Shofu Inc., Kyoto, Japan) in June 2012. Occlusal adjustment of these superstructures was performed with mutually protected occlusion. Dental implant maintenance by professional care was performed every 6 months after completion of implant treatment. At 7 months after prosthetic treatment, in March 2013, the abutment and superstructure of the maxillary left lateral incisor implant were refabricated due to partial fracture of the zirconia abutment caused by crown loosening. At over 5 years after implant surgery and 4 years after final restoration (November 2016), progress was uneventful, with no prosthetic complications, inflammation of the peri-implant soft tissue, and/or bone resorption (Figs. 8, 9).

**Discussion**

Computer-assisted surgery was performed to avoid complications such as damage to the roots of the adjacent teeth in a case where insufficient space had been left for placement of an implant by bilateral agenesis of the maxillary lateral incisors. One meta-analysis has shown that tooth agenesis in Caucasian patients most commonly affects the mandibular second premolar (41.0%), followed by the maxillary lateral incisors (22.9%), and the maxillary second premolar (21.2%)\(^5\). Agenesis of the maxillary lateral incisor was reported to have the fourth highest incidence\(^5\) and bilateral agenesis to most commonly affect the Japanese\(^17\). The mean width
of the maxillary lateral incisor has been reported to be $7.07\pm0.43$ mm, and be smallest in the maxilla$^{13}$. Implant-tooth distance should be greater than 1.5 mm to 2.0 mm to avoid various complications, including peri-implant bone loss and damage to the adjacent tooth root. Therefore, a minimum mesiodistal space of 6 mm is required for a single missing intermediary tooth, with the diameter of the implant being 3.3–3.5 mm$^{8,9,11,16}$. With maxillary lateral incisor agenesis after deciduous tooth loss, the mesiodistal space may be insufficient for implant insertion if the adjacent teeth tilt into the edentulous area. Moreover, even if the mesiodistal space is preserved by the presence of a deciduous tooth, it will be too narrow for implant fixture insertion following tooth extraction, as the width of the crown of the deciduous maxillary lateral incisor is less than 6 mm (male, $5.50\pm0.43$ mm; female, $5.35\pm0.43$ mm)$^{6}$. For these reasons, agenesis of the maxillary lateral incisors often results in a deficiency in the mesiodistal space for implant placement.

In the present case, there was a significant bilateral deficiency in the mesiodistal space at the initial examination, which was subsequently improved by orthodontic treatment. The risk of damage to the adjacent tooth by inaccuracy in the directionality of drilling remained, however, as these spaces were still only approximately 6.0 mm. Recently, computer-assisted implant surgery employing a surgical template fabricated based on planned data using computerized patient CT data and implant simulation software has been used to increase the accuracy of implant positioning. This has also been helped by the development of stereolithographic technology, which allows the faithful reproduction of 3-dimensional virtual data, and computer-assisted design and manufacturing (CAD/CAM) technology$^{4,5}$. Some studies reported that
deviation in the implant position between at preoperative planning and postoperative implant placement with computer-assisted surgery was within approximately 1 mm, and that of angle deviation approximately 5°. One in vitro study also revealed that implant placement with a surgical template reproduced the planned position more accurately than conventional freehand insertion\(^\text{19}\). In addition, in another study, use of implant positioning based on virtual planning data and a surgical template in patients with Kennedy Class II mandibular defects was more accurate than conventional freehand implant insertion in the anatomical cast of the same patient. Deviation in actual implant placement using a surgical template (implant shoulder, 0.9 mm; implant apex, 0.6–0.9 mm) was significantly smaller than that with conventional free-hand placement (implant shoulder, 2.4–3.5 mm; implant apex, 2.0–2.5 mm)\(^{\text{12}}\). Surgical templates can be categorized into 3 types depending on where they are placed: 1) tooth-supported; 2) mucosa-supported; and 3) bone-supported. One in vitro experiment comparing the accuracy of these 3 different types of surgical template revealed no statistically significant difference in angular deviation. On the other hand, liner deviation at the implant neck and apex with the tooth-supported surgical template was the lower than that with the other 2 templates, and a significant difference was observed between the tooth-supported and mucosa-supported surgical templates (\(p<0.05\))\(^{\text{18}}\). These results suggest that computer-assisted implant surgery using a tooth-supported surgical template is suitable in cases of intermediary missing teeth with a narrow mesiodistal space for implant placement. However, implant placement with surgical templates is associated with several complications, particularly a significant risk of overheating bone tissue during drilling with insufficient irrigation due to the mounting of the surgical template\(^{\text{20}}\). This was avoided in the present case by performing open flap implant surgery and creating a window on the buccal side of the surgical template to allow irrigation with additional saline water.

Partial fracture of the zirconia abutment occurred at 7 months after prosthetic treatment. Possible reasons for this complication are as follows: 1) use of zirconia as the abutment material and the thinness and unevenness of the material around the access hole; and 2) exertion of abnormal occlusal force on a loose superstructure due to temporary cementation. To avoid this potential complication, we proposed some corrective strategies, including the use of higher-strength abutment material such as titanium and/or a retaining superstructure by permanent cement to prevent superstructure loosening. The patient disagreed with these proposals, however, as they would have incurred a negative esthetic effect due to the visibility of metal color by gingival recession and the loss of removability to enable retightening of the abutment screw without destroying the superstructure. Furthermore, the interval of routine maintenance was reduced to ensure rapid detection of superstructure and/or abutment screw loosening to prevent fracture of the prosthesis. At 4 years after refitting the superstructure, there were no complications, including inflammation of the peri-implant soft tissue, resorption of peri-implant bone, and prosthetic problems such as abutment and/or superstructure looseness.

In cases of bilateral agenesis of the maxillary lateral incisors, the edentulous spaces will be too narrow to place an implant, and there is a high risk of damaging the adjacent tooth root due to inaccuracies in the directionality of drilling. Computer-assisted implant surgery, which allows more accurate placement of the implant body than the freehand method, is useful in avoiding the complications associated with such cases.

**Acknowledgements**

We would like to sincerely thank Dr. Junya Nagata and Dr. Satoshi Togo at the Department of Orthodontics, Tokyo Dental College, for their academic advice on this work.
References


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