Case Report

The Application of Maxillary Orthognathic Surgery and Implant Supported Fixed Dental Prostheses to Reconstruct a Patient with Skeletal Class III Jaw Relationship

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Abstract

In patients with a maxillary partially edentulous ridge and Class III jaw relationship, it is difficult to establish a clinical outcome with adequate esthetics and function by using implant-supported fixed dental prostheses (FDPs). This report presents the case of a female patient with a skeletal Class III jaw relationship whose maxillary teeth, other than the third molars, had all been extracted because of advanced chronic periodontitis. Because the patient did not want to wear removable prostheses, implant-supported FDPs were planned for her. An interdisciplinary treatment approach combining maxillary orthognathic surgery (i.e., Le Fort I osteotomy) for maxilla advancement with subsequent iliac onlay bone grafting and computer-guided flapless implant surgery and reconstruction with modified monolithic zirconia implant-supported FDPs was used to treat the patient. The pre-surgical, surgical, laboratory, and prosthetic stages and 18-month follow-up outcomes are described, with the outcomes indicating complete arch rehabilitation. Finally, we met the treatment goals of rehabilitation of the patient's chewing function and a satisfactory appearance when smiling.

Keywords: orthognathic surgery, Class III jaw relationship, modified monolithic zirconia, computer-guided implant surgery

Introduction

Adequate bone volume and an ideal interarch relationship are the basic criteria for restoration of the edentulous maxilla with implant-supported fixed dental prostheses (FDPs). An ideal alveolar bone position in a Class I relationship with an opposing arch is suitable for optimal implant placement and restoration. Implant prosthetic horizontal cantilever can be minimized and cross-bite occlusion can be prevented.[1] However, in patients with a maxillary fully edentulous ridge and Class III jaw relationship, it is difficult to establish a clinical outcome with adequate esthetics and function by using implant-supported fixed dental prostheses (FDPs). When the horizontal discrepancy of the ridge relationship is too large, a Class I ridge relationship is unachievable with bone graft reconstruction alone.[2] Rather, an interdisciplinary treatment approach combining maxillary orthognathic surgery (i.e., Le Fort I osteotomy) for maxilla

Fig. 1: Patient with Class III jaw relationship with concave lateral profile and obtuse nasolabial angle.

advancement with onlay bone grafting and implant therapy should be applied in such cases in order to achieve an ideal clinical outcome.

To improve the esthetic outcome of implant-supported FDPs, all-ceramic materials have become popular. However, although these materials are superior to metals in terms of their biocompatibility, esthetics, and lower thermal conductivity, their load bearing capacity is relatively low. As such, higher failure rates have been reported for ceramic partial FDPs and posterior single crowns compared with traditional metal ceramic prostheses.[3,4] The most frequent reason for the failure of FDPs made out of glass-ceramics or glass-infiltrated ceramics has been reported to be fracture of the reconstruction (i.e., the framework and veneering ceramic)[4].

Compared to glass-ceramics, Yttria-stabilized tetragonal zirconia polycrystal (Y-TZP) ceramics have excellent mechanical properties because of the stress-induced phase transformation[5]. According to previous clinical studies, zirconia framework fracture was found in 0%~2.2% of zirconia FDPs[6] after 3~5 years of clinical service. However, the complication rate of veneering porcelain chipping was 15.2%~32% in zirconia-based FDPs[6-8], which was much higher than the chipping rate of metal-ceramic FDPs (5%~19.4%)[6,9]. There are, however, some solutions for decreasing the rate of ceramic chipping. These methods include the use of CAD/CAM-fabricated high-strength anatomically shaped veneering caps sintered onto zirconia coping[10,11], slow cooling and heating regimens when firing porcelain to zirconia[12], and monolithic zirconia restorations without the application of veneering porcelain[13]. However, reduced light transmission may compromise the esthetic outcome of FDPs made from monolithic zirconia. Therefore, zirconia-based FDPs with modified monolithic designs were introduced.[14] The occlusal surfaces of these FDPs are made from zirconia, with veneering porcelain being applied on the facial surfaces only. This framework design can improve esthetics and reduce veneering porcelain fracture.

This case report introduces the method of maxillary orthognathic surgery (i.e., Le Fort I osteotomy) for maxilla advancement, followed by iliac onlay bone grafting and computer-aided implant placement, to reconstruct a patient with a Class III jaw relationship. A modified monolithic zirconia design was adopted for the fabrication of definitive prostheses in order to improve their esthetics and reduce mechanical complications.

Clinical report

A 50-year-old female patient came to the Department of Prosthodontics at Chi Mei Medical Center with the chief complaints of severe mobility of her upper anterior FDP and impaired chewing function. Extra-oral examination revealed a Class III jaw relationship with a concave lateral profile (Fig. 1). The patient's lip support was insufficient and the

Fig. 2: initial photographs illustrates the maxillary teeth were in a retrognathic position related to mandible and with an anterior crossbite occlusion.

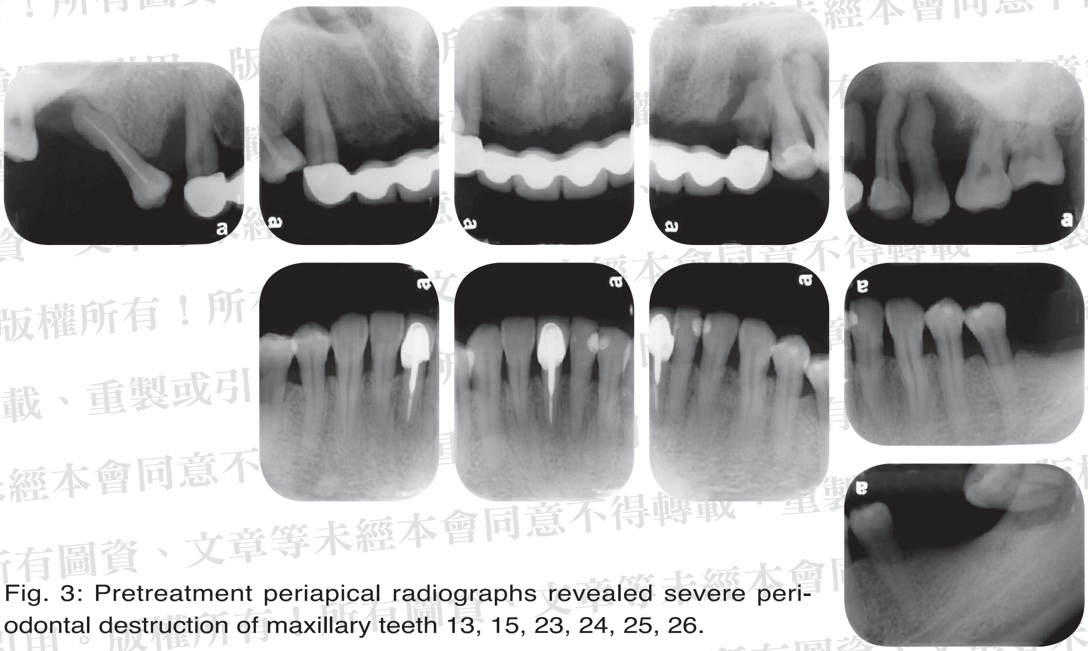

Fig. 3: Pretreatment periapical radiographs revealed severe periodontal destruction of maxillary teeth 13, 15, 23, 24, 25, 26.

Fig. 4: Clinical examination 4 months after tooth extraction. Maxilla was in a retrognathic position related to mandible.

nasolabial angle was obtuse. Intra-oral examination showed an ill-fitted long span metal-ceramic FDP with an anterior crossbite occlusion (Fig. 2). The periapical radiographs revealed severe periodontal destruction of teeth 13, 15, 23, 24, 25, and 26 (Fig. 3). Treatment began with the extraction of all the patient's maxillary teeth except the third molar. The interim denture was delivered immediately after this tooth extraction. Insufficient bone volume was noted 4 months after the extraction of the maxillary teeth. The maxilla was in a retrognathic position related to the mandible (Fig. 4) and a lateral cephalometric radiograph and cast analysis revealed a skeletal Class III jaw relationship (Fig. 5).

After comprehensive clinical and radiographic examinations, the following potential treatment plans for the maxilla were developed and explained to the patient: (1) an implant-

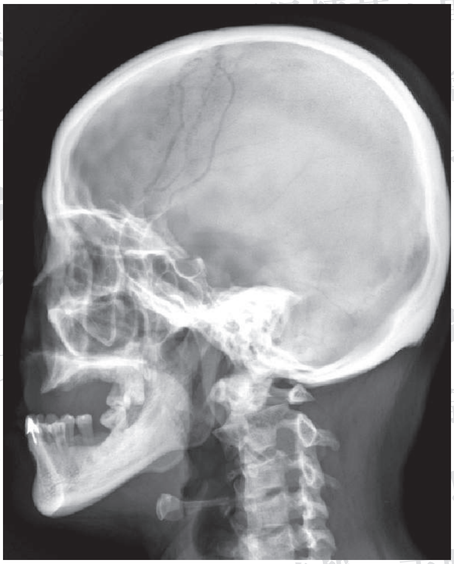

Fig. 5: Lateral cephalometric radiograph revealed skeletal Class III jaw relationship.

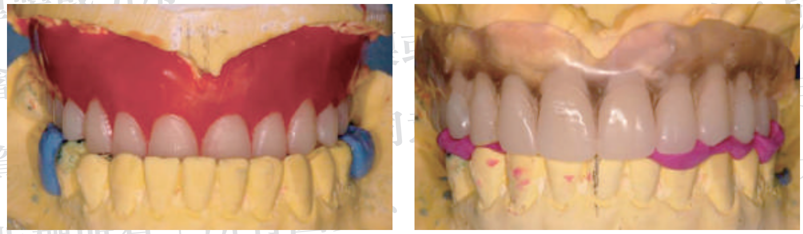

Fig. 6: Surgical stent fabrication and model surgery for orthognathic surgery.

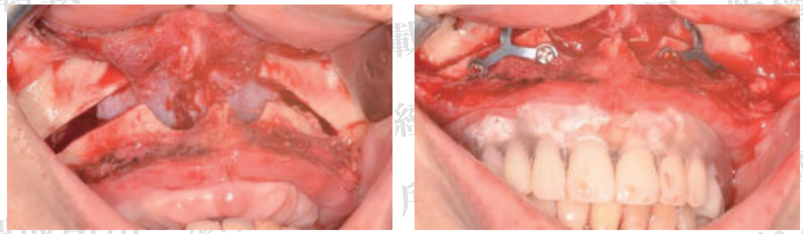

Fig. 7: Maxillary orthognathic surgery (Le-Fort I osteotomy) with the aid of surgical stent.

supported overdenture, (2) implant-supported FDPs with crossbite occlusion, (3) guided bone regeneration with iliac bone block to correct the large horizontal discrepancy and implant-supported FDPs with normal overbite and overjet, and (4) orthognathic surgical correction combined with iliac bone grafting and implant-supported FDPs with normal overbite and overjet. Because the patient did not want to wear a removable prosthesis, she decided to receive implant therapy with implant-supported FDPs. An interocclusal centric relation record was taken with a maxillary occlusion rim, and 2 different kinds of diagnostic wax patterns were established with crossbite and positive overjet occlusions, respectively. Two radiographic stents were fabricated based on the diagnostic wax patterns and then tried out clinically. Because the patient's lip support was insufficient and the nasolabial angle was obtuse with the stent with anterior crossbite, it was expected that it could be difficult to achieve an esthetic outcome with an occlusal scheme with anterior crossbite. In addition, there was no anterior guidance to help disocclude the posterior teeth during eccentric movement.

A computed tomography (CT) scan was taken with the stent with normal overbite and overjet. The CT image of the normal overbite and overjet showed a large horizontal discrepancy and revealed that a large quantity of bone graft was needed for a normal occlusal scheme. If, on the other hand, a normal occlusal scheme was planned without orthognathic surgery, the horizontal discrepancy would be too large, and the outcome of any guided bone regeneration might be unpredictable. The CT images also showed a narrow maxillary anterior alveolar ridge (about 4 mm) and insufficient bone width for adequate primary implant stability.

Based on the above-mentioned conditions, it was concluded that a maxillary orthognathic surgery (i.e., Le Fort I osteotomy) combined with iliac bone grafting should be conducted for implant site development and to achieve a Class I jaw relationship with adequate overbite and overjet. Guided bone regeneration with iliac bone block would then still be needed after the orthognathic surgery because of the insufficient bone width. However, the amount of guided bone regeneration required could largely be decreased with the aid of maxilla advancement. The centric relation record was registered with a maxillary occlusion rim, and a new surgical stent was made based on the position of the maxillary alveolar ridge and the CT image. In addition, the surgical stent was made in the new maxillary position. Moreover, a model surgery was performed to simulate the utilization of the Le Fort I osteotomy to advance the maxilla anteriorly, and the surgical stent was positioned with normal overbite and overjet in the new maxillary position. (Fig. 6)

During the maxillary orthognathic surgery, the Le Fort I osteotomy was performed for maxillary advancement with the aid of the surgical stent (Fig. 7). Thereafter, the maxilla was secured with internal rigid fixation by using

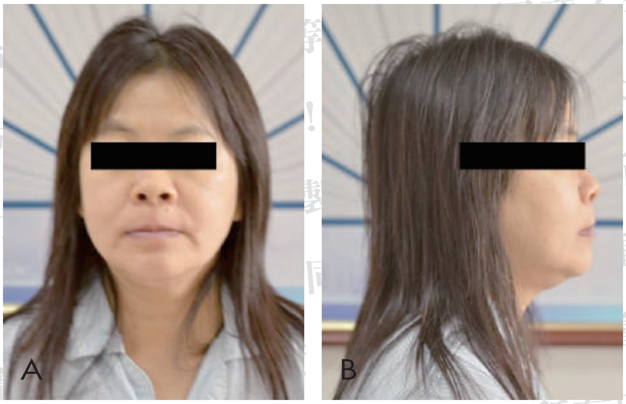

Fig. 8: Facial profile after orthognathic surgery (Post OgS 6 months).
Class I jaw relationship with apropriate nasolabial angle was achieved.

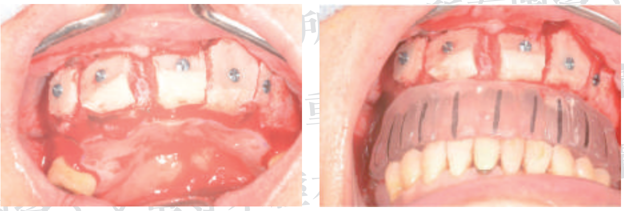

Fig. 9: Ridge augmentation with iliac onlay bone graft was performed due to insufficient bone volume for implant placement.

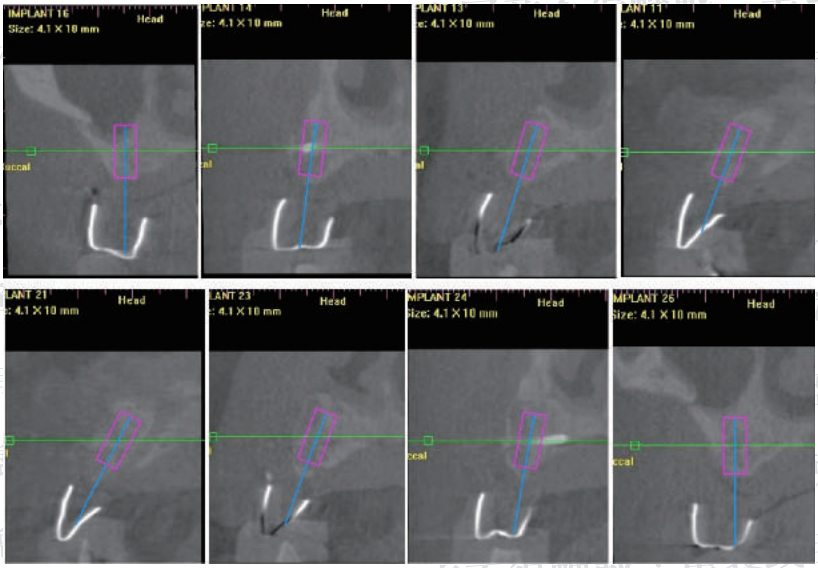

Fig. 10: Implant planning in computer software.

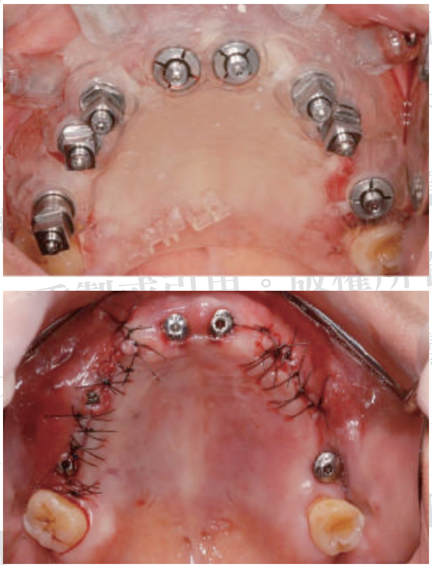

Fig. 11: Computer-guided implant surgery.

titanium miniplates and screws. After wound healing, a second interim denture was delivered for the patient. A Class I jaw relationship with a better nasolabial angle was achieved after the orthognathic surgery (Fig. 8). Ridge augmentation via the use of iliac onlay bone grafting was then performed 6 months after the orthognathic surgery due to the insufficient bone volume for implant placement (Fig. 9).

5 months after the iliac bone grafting, a radiographic stent was fabricated based on the diagnostic wax patterns and then tried out clinically at an evaluation appointment, and a double CT scan was performed. The data from the CT scan were reformatted, and a 3-D implant planning software program (Nobel Guide; Nobel Biocare USA, Yorba Linda, Calif)15 was used to plan the ideal implant locations virtually. The CT images showed adequate bone width and height for implant placement (Fig. 10). Subsequently, the virtual implant planning was sent via email to a rapid prototyping manufacturing facility (Procera; Nobel Biocare USA) for fabrication of the maxillary stereolithographic surgical template. After receipt of the stereolithographic template and associated laboratory prosthodontic procedures, the maxillary CAD/CAM-guided flapless implant surgery was scheduled and performed with strict adherence to the surgical protocol. Eight implants (Branemark System MKIII or NobelSpeedy™ Groovy, Nobel Biocare) were placed in the maxilla with the aid of the computer-guided surgical stent (Fig. 11).

Fig12: Complete-arch implant-supported provisional restoration was inserted clinically.

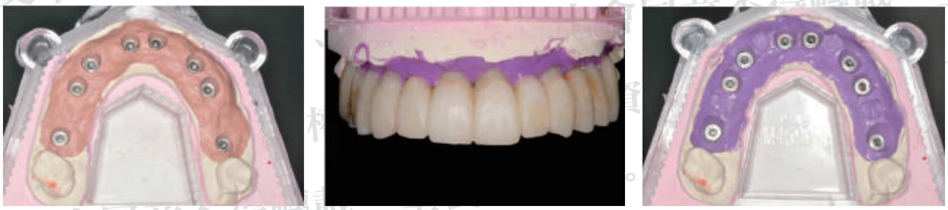

Fig. 13: Provisional prosthesis was utilized to make definitive cast with accurate soft tissue profile.

Fig. 14: Accurate interocclusal registration was recorded by using provisional prosthesis.

After 3 months of osseointegration, a complete-arch impression was made with polyvinyl siloxane (Aquasil Ultra XLV and Aquasil Soft Putty; Dentsply Caulk, Milford, Del) using an open tray technique. An interocclusal centric relation record (Futar D; Kettenbach GmbH & Co KG, Eschenburg, Germany) was taken with an occlusion rim to fabricate the provisional prosthesis, and a complete-arch implant-supported provisional restoration was inserted clinically (Fig. 12). A periapical radiograph showed an accurate marginal fit for the provisional FDPs. Two implants (NobelReplace™ Conical Connection) were inserted into the edentulous sites of the 36 and 46 positions. No technical complications, such as screw loosening or prosthetic fractures, were noted during the follow-up period.

Provisional prosthesis was utilized to transfer the emergence profile with polyvinyl siloxane (Panasil, light body, Kettenbach Dental, Eschenburg, Germany) and to transform the original model used for the fabrication of the provisional FDPs to the definitive model (Fig. 13). The provisional prostheses were also utilized to take the interocclusal record instead of the maxillary occlusion rim (Fig. 14). Subsequently, the maxillary and mandibular definitive models along with the provisional prosthesis were mounted in a semiadjustable articulator to obtain an accurate maxillomandibular relationship (Hanau Modular Articulator System 190; Whip Mix Corp, Louisville, Ky). The maxillary definitive implant-supported FDPs were designed with a segmented modified monolithic zirconia framework. The framework was milled from partially sintered zirconia blocks (Ceramil zi; Amann Girrbach AG) and fully sintered at a temperature of 1450°C and was then evaluated intraorally. The accuracy of the marginal fit was confirmed clinically and with periapical radiographs. The facial surfaces of the zirconia framework were veneered with feldspathic porcelain (Vita VM9; Vita Zahnfabrik, Bad Sackingen, Germany) to complete the modified monolithic zirconia FDPs. Red articulating paper (AccuFilm II; Parkell Inc, Edgewood, NY) and shimstock foil (GMH; Hanel Medizinal, Nurtingen, Germany) were used for occlusal assessment, and minor occlusal adjustments was performed with a zirconia polishing kit (Ceramil polish - lab kit; Amann Girrbach AG). The eccentric occlusal scheme of bilateral group function was thus established.

The implant-supported zirconia-based FDPs with modified monolithic design were then inserted and a radiographic examination confirmed their accurate marginal adaptation. The screw-retained FDPs were tightened with 35 Ncm torque, and the screw-access channels were sealed with gutta percha (Temporary

Fig. 15: Intraoral photographs after insertion of modified monolithic zirconia implant-supported FDPs.

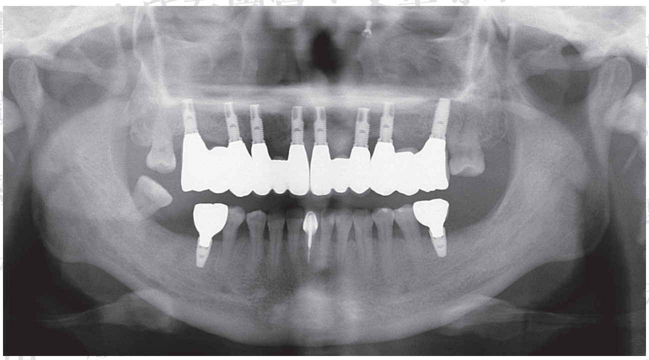

Fig. 16: Panoramic radiograph after insertion of definitive FDPs.

Fig. 17: Facial profile after delivery of definitive FDPs. Adequate lip support and favorable facial profile was achieved.

stopping; GC) and light-polymerized composite resin (Filtek Z250; 3M ESPE). After delivery of the definitive FDPs, the patient, who had originally had a skeletal Class III jaw relationship, had adequate lip support and a favorable profile (Figs. 15-17). No biological or technical complication was found during the subsequent 18-month follow-up period (Figs. 18 and 19).

Discussion

In cases with atrophic maxilla and a Class III jaw relationship, as the extent of resorption increases, the vertical and horizontal deficiencies become more pronounced. For this reason, not only the available bone volume but also the three-dimensional interarch relationship should be evaluated when implant therapy is considered for the atrophic maxilla.[16]

Implant treatments for patients in this situation include the following options: (1) an implant overdenture, (2) implant-supported FDPs with crossbite occlusion, and (3) surgical correction to achieve a Class I jaw relationship

Fig. 18: Clinical examinations 18 months after definitive prostheses insertion.

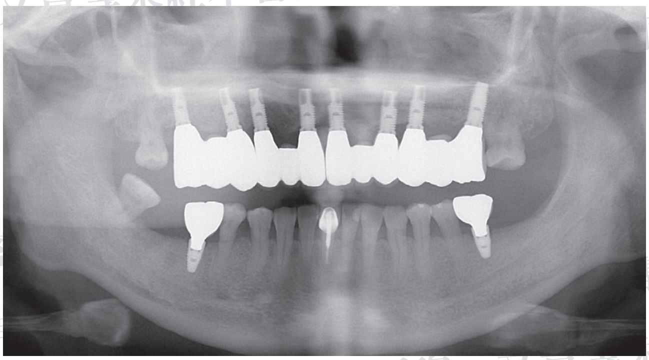

Fig. 19: Panoramic examination 18 months after definitive prostheses insertion

in conjunction with implant-supported FDPs with adequate overbite and overjet. Because the patient in this case did not want to wear a removable prosthesis, the implant overdenture option was excluded. Although implant-supported FDPs with crossbite occlusion can restore occlusion, some problems may arise in terms of anterior crossbite. Also, acceptable esthetic outcomes may be difficult to achieve if the retrognathism of the maxilla is severe. No anterior guidance to help disocclude posterior teeth upon anterior movement.[17] A buccal cantilever would be presented if normal overbite and overjet is required. The presence of a large cantilever with implant prostheses can generate overloading, possibly resulting in peri-implant bone loss and prosthetic failure.[18,19] Therefore, surgical correction to achieve a Class I jaw relationship and implant-supported FDPs with adequate overbite and overjet may be appropriate for this kind of patient. Maxillary orthognathic surgery (i.e., Le Fort I osteotomy) for maxilla advancement combined with onlay bone grafting can be used to improve the ridge relation and increase the bone quantity. In this case, an interdisciplinary treatment approach combining maxillary orthognathic surgery (i.e., Le Fort I osteotomy) for maxilla advancement with subsequent iliac onlay bone grafting and reconstruction with modified monolithic zirconia implant-supported FDPs was used to treat the patient exhibiting skeletal class III malocclusion. As a result, the following outcomes were achieved: adequate lip support, a favorable profile, a Class I jaw relationship, and appropriate anterior guidance.

With conventional surgery, the information from the CT image is not directly transferred to the actual implant surgery.[20] A computer-guided implant surgery, in contrast, uses CT scans to aid in the planning of the surgery and to produce surgical drilling guides. This kind of surgical template allows for the placement of the implants only at well-defined points, because the drills are guided precisely by corresponding sleeves.[21] This method is therefore more precise than the conventional approach and can decrease the rate of complications such as nerve damage, sinus perforation, and dehiscence.[20] Because the prosthetics used in this case consisted of segmental FDPs, the accuracy of the implant locations was more critical than it would be for other treatment options such as an implant overdenture, hybrid denture, or complete-arch implant-supported FDPs. Therefore, computer-guided implant surgery was conducted in this case.

Veneering porcelain chipping rates for zirconia-based tooth-supported FDPs have been reported to range from 15.2% to 32%.[6-8] In the present clinical report, the framework was designed with monolithic zirconia occlusal surfaces to minimize the possibility of the veneering porcelain being chipped, and the veneering porcelain was applied only on the facial surfaces to improve the esthetic outcome.[12] Stress-generated surface treatments of zirconia such as occlusal adjustment will trigger the tetragonal and monoclinic phase transformation, which may compromise the mechanical properties of the zirconia. A screw-retained provisional prosthesis instead of an occlusion rim was thus used to obtain an accurate interarch relationship in this case in order to minimize the possible occlusal errors and decrease the amount of occlusal adjustment required.[22]

There are several methods for replicating the healed tissue morphology around an implant. One method consists of connecting customized impression copings fabricated by autopolymerizing acrylic resin (Pattern Resin; GC America, Inc, Alsip, IL) to an implant intraorally in order to make a definitive impression.[23] The present case, however, involved the use of multiple segmental implant-supported FDPs, such that it would have been overly time-consuming to use the customized impression coping method. Therefore, provisional prostheses were utilized to transfer the soft tissue morphology and emergence profile.[24] Such provisional prostheses can also be utilized for mounting a definitive cast at the same appointment, thus decreasing appointment times and simplifying the treatment.

Recent systematic reviews have shown that biological and technical complications of complete-arch implant-supported FDPs occur frequently.[25] Therefore, a segmented prosthetic design with multiple short-span FDPs may be recommended for complete-arch implant rehabilitation because of their greater hygiene, greater ease of fabrication, and easier prosthetic maintenance. For the present clinical report, a segmented prosthetic design was adopted accordingly.

The treatment strategy involving orthognathic surgery described in this case could be an alternative to prosthetic rehabilitation for patients with a Class III jaw relationship. Although this approach may require more extensive surgery initially, the resulting prognosis may be more promising in the long-term. However, longitudinal follow-ups and evaluations are still necessary to ensure a predictable outcome.

Conclusion

In order to achieve an ideal clinical outcome by using implant-supported FDPs to reconstruct a patient with a skeletal Class III jaw relationship, an interdisciplinary treatment combining orthognathic surgery with iliac bone grafting should be considered to achieve sufficient bone volume and an adequate three-dimensional interarch relationship.

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