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ALLOPLASTIC RECONSTRUCTION OF THE TEMPOROMANDIBULAR JOINT

Temporomandibular Eklemin Alloplastik Rekonstrüksiyonu

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ABSTRACT

Temporomandibular joint reconstruction (TMJR) is often necessary for patients with severe and/or refractory TMJ disease who have failed conservative treatment. TMJR aids to improve masticatory function and is associated with improved quality of life outcomes. Currently, alloplastic reconstruction is considered as the treatment of choice in most severe TMJ disorders due to its many advantages inclusive but not limited to early mobilization, stable long-term results, and significant improvement in jaw function. Broadly speaking, two types of TMJR prostheses are available for reconstruction: 1) stock, and, 2) custom-made prostheses. The purpose of this article is to provide the reader with a brief overview of the basic principles and fundamentals of TMJR while referencing pertinent existing literature.

Keywords: *Alloplastic; temporomandibular reconstruction; prostheses; custom-made; stock*

ÖZ

Temporomandibular eklem rekonstrüksiyonu (TMER); konservatif tedavinin başarısızlıkla sonuçlandığı ciddi Temporomandibular eklem (TME) hastalığı olan bireyler için gerekli olabilmektedir. TMER, çiğneme fonksiyon bozukluğunu iyileştirmekte; dolayısıyla hayat kalitesini artırmaktadır. Günümüzde; alloplastik rekonstrüksiyon, ilerlemiş TME hastalıklarında erken mobilizasyonun sağlanması, stabil uzun dönem sonuçların kazanımı ve çene fonksiyonunun iyileştirilmesi gibi avantajları nedeniyle tedavi seçeneği olarak göz önünde bulundurulmaktadır. Genel olarak iki tip TME eklem protezi bulunmaktadır: 1) hazır eklem protezi 2) kişiye özgü eklem protezi. Bu makalenin amacı, mevcut literatür dahilinde, okuyuculara TME protezlerinin temel prensipleri ve esasları hakkında genel bilgi sağlamaktır.

Anahtar kelimeler: *Alloplastik, temporomandibular rekonstrüksiyon; protez; kişiye özgü TME protezi; hazır eklem protezi*

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Introduction

Although many temporomandibular joint (TMJ) disorder patients are initially managed with non-surgical and conservative therapies, some patients with end stage pathology and severe physiologic dysfunction dictate the need for total temporomandibular joint reconstruction (TMJR). The goal of TMJR is to restore mandibular form and function (1). While both autogenous and alloplastic reconstruction have been described in the literature, this review will largely focus on alloplastic reconstruction, which over the last decade or so has become the standard of care and most commonly employed form of TMJR in the developed world. Alloplastic TMJR provides a biomechanical rather than a biologic solution for treatment of severe joint disease (2).

There is sufficient evidence to support the fact that alloplastic TMJR leads to increased mouth opening, improved quality of life, decreased pain and diet limitations, and improved essential life functions such as mastication, speech and deglutination. Studies report that up to 88% of TMJR patients experience long term quality of life improvement as a result of decreased pain and increased mandibular function (3-5). It is estimated that by the year 2030, there will be almost 902 (58% increase) TMJR surgeries performed in the USA annually to manage end stage TMJ disease (6). With such an increased need, it is necessary for the specialty of Oral and Maxillofacial Surgery (OMFS) to adequately train its residents in TMJR so that patient needs can be adequately met. In a recent survey based assessment of resident training and exposure to TMJR in their OMFS programs, 94% of the respondent program directors reported scheduled didactic courses on TMJR with only 25% of responding programs performing more than 10 cases annually (7).

Numerous alloplastic materials have historically been used for TMJR. Previous systems containing Proplast-Teflon (Vitek Kent, Houston, Texas) and Silastic have been removed from the market due to foreign body giant cell reaction and increased wear. Most modern day systems are composed of Cobalt-Chrome-Molybdenum (Co-Cr-Mo) or Titanium (Ti) condylar components with ultrahigh molecular weight polyethylene (UHMWPE) based fossa components. Currently, there are two types of TMJR prosthesis systems that are approved by the Food and Drug Administration (FDA) in the USA, and these are: 1) Stock Fit prostheses that are available in different prefabricated sizes and shapes based on mean measurements of the TMJ and 2) Custom-made prostheses which are individual patient fitted replacements.

Indications for the procedure

Indications for TMJR have been proposed by numerous organizations including the National Institute for Health and Care Excellence (NICE) in May 2014(8) and the British Association of Oral and Maxillofacial Surgeons in 2008(9), both of which are widely accepted.

They include bony ankylosis, failed previous alloplastic and autogenous joint replacement, post-traumatic condylar injury, avascular necrosis, reconstruction after tumor ablative surgery, developmental abnormalities, functional deformity and severe inflammatory conditions that have failed to respond to conservative treatment.

Contraindications for the procedure

There are only very few instances where TMJR is absolutely contraindicated, and most commonly this occurs when patients have an active infection and/or those with documented allergy to the implant components. Placement of the prosthesis in a site with acute infection can lead to micro-motion and difficulty to stabilize the prosthesis, ultimately leading to failure. Allergy to alloy components may be present before or may manifest after placement of the prosthesis, and are generally type IV delayed hypersensitivities.

Placement of fat grafts around the head of the condylar components to decrease tissue exposure to alloy components has been previously proposed by some authors (10, 11), and although this approach is reasonable, there is no objective scientific evidence to support the hypotheses. Hussain and colleagues report encouraging results in patients with allergy to metal components (cobalt, chromium, nickel and molybdenum) where all-titanium prostheses were placed. In their study, similar symptomatic relief was achieved with titanium-only joints as compared to standard TMJR prosthesis and no hypersensitivity reactions were encountered (12).

Other conditions where TMJR may be relatively contraindicated include patients with uncontrolled systemic disease along with those who are not

psychologically prepared and have unrealistic expectations from the procedure. The authors recommend that prospective patients should be encouraged to complete a preoperative psychological evaluation if they do not appear to have realistic expectations from the replacement procedure. Lastly, it is important to take into consideration the age of the patient. TMJR devices do not have any growth potential, which may necessitate reoperation in the future and the life span of the device is a concern in the younger patient population. There is a paucity of evidence-based data to approach TMJR in children with the exception of some case studies (13).

Having said that, recently there has been much discussion amongst TMJ experts and it is likely that the use of alloplastic TMJR will continue to increase in the pediatric population since such surgery may significantly improve the quality of life and decrease many of the functional limitations that severely affected children who are TMJR candidates have.

Historical considerations

In 1974, Kiehn *et al.* attempted to construct a TMJR prosthesis from principles applied to total hip replacement consisting of a vitallium mandibular fossa plate and ramus condyle unit (14). Several prostheses were developed in the coming years but in 1982, the *Vitek-Kent* Proplast-Teflon (PT) containing prosthesis was created (Vitek, Inc., Houston, Texas) and this specific prosthesis became popular due to encouraging early reports.

However, on continued long term follow-up, patients were found to develop pain, malocclusion, condylar resorption and a foreign body giant cell reaction (15, 16). The system was subsequently removed from the market (by the FDA) due to multiple failures. In 1989, *Techmedia i*ntroduced the TMJ concepts prosthesis as a custom fit total TMJR system that was built from CT scan data and designed using a CAD/CAM system. It was granted FDA approval in 1997 and has been widely used since then. Its name was subsequently changed to *TMJ Concepts* and it has definitely paved way for several newer generations of TMJ prostheses.

Ideal requirements of TMJ prosthesis

For a TMJR prosthesis to be successful, it must meet some broad biological and mechanical characteristics. There are three major requirements: 1) Simulation of functional TMJ movements, 2) Close adaptability, and, 3) ln-vivo longevity (17-19). With regards to simulation of TMJ movements, any prosthesis should be able to imitate the translational movement of the condyle without restricting the movements of the uninvolved/nonreplaced contralateral joint. Choosing a material with the appropriate mechanical properties in terms of tensile strength, hardness, elasticity, and fatigue coefficients will prevent stress from being transferred to the adjacent bone, preventing bone resorption and implant loosening. Secondly, to obtain an accurate and close fit to the anatomic structures, the prosthesis surface and material must allow for new bone formation and cell proliferation for adequate osseointegration. Lastly, biological properties such as biocompatibility, inertness, corrosion resistance and low wear rates affect the long term in-vivo success of any prosthesis.

Types of TMJ prosthesis

In the US, there are three TMJR systems currently available: 1) Patient fitted TMJ concepts system (Ventura, CA, USA) (Figure 1), 2) Stock Biomet microfixation system (Jacksonville, FL, USA) (Figure 2), and, 3) Stock and custom fit Nexus CMF system (Salt lake city, UT, USA) (Figure 3)

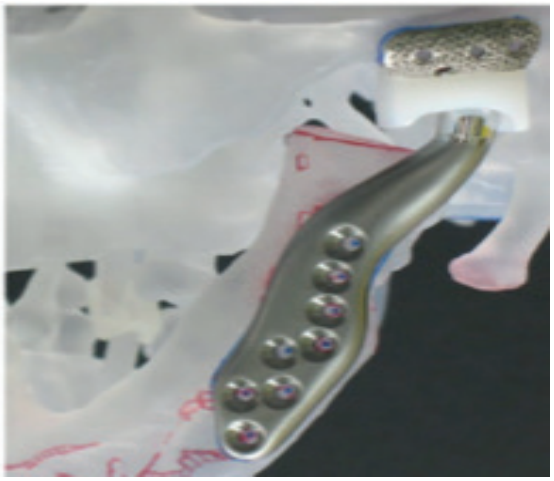


Figure 1. *TMJ concepts prosthesis (reproduced from: tmjconcepts.com).*

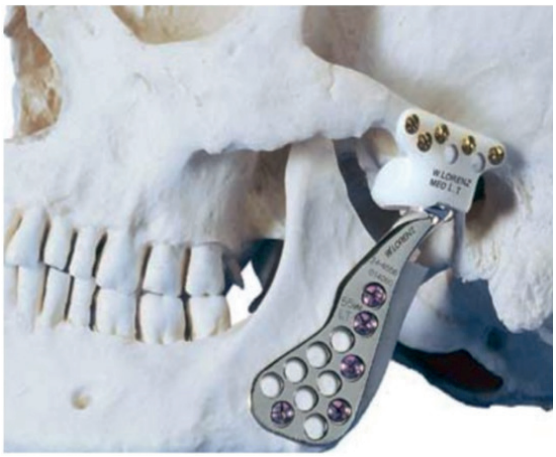


Figure 2. *Biomet microfixation system prosthesis (reproduced from: biomet.com).*

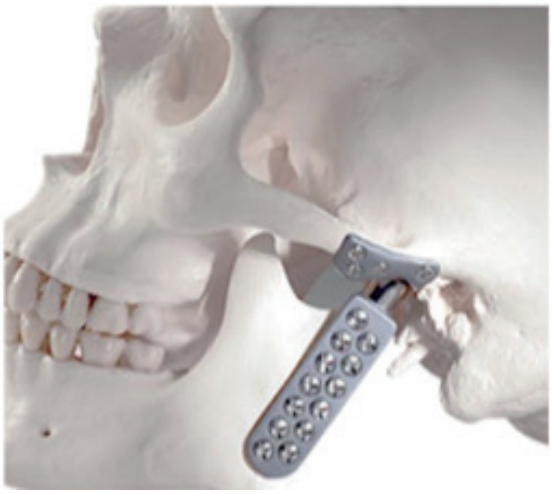


Figure 3*. Nexus CMF system prosthesis (reproduced from: nexuscmf.com).*

Each of the above mentioned systems have three basic components: 1) Condyle and Ramus component (Co-Cr alloy for Biomet and Nexus and Ti alloy ramus component and Co-Cr-Mo condyle for TMJ Concepts), and, 2) Fossa component (UHMWPE for Biomet, pure Ti backed mesh with UHMWPE for TMJ concepts and Co-Cr fossa for Nexus), and, (3) Fixation screws (Ti alloy for TMJ Concept and Biomet and Co-Cr for Nexus). In a recent review and meta-analysis of currently available total TMJR prosthesis (20), there was no significant difference noted between various TMJR systems in terms of pain or diet scores. A prospective outcomes review by British surgeons in 2014 using the TMJ concepts system showed, significant improvements in pain scores (7.4 reduced to 0.6 at 3 years and 0.8 at 5 years), maximum incisal opening (21.0mm improved to 35.5 mm at 3 years and 23.8mm improved to 33.7 mm at 5 years), and dietary scores (improved from 4.1 to 9.7 at 3 years and from 3.7 to 9.6 in the 5 year group) (21). Similarly, a review of outcomes performed by the TMJ surgeons at University of Florida with the Biomet stock implants demonstrated improved mean mouth opening from 26.1 mm preoperatively to 34.4 mm postoperatively, decreased pain score from 7.9 to 3.8 and improvement in dietary restriction from 6.8 to 3.5 (22). Several other studies with results in favor of significant reduction in pain symptoms and improvement in dietary function and mouth opening have been reported in the literature (5, 23, 24). However, there is still a paucity in terms of prospective long-term data and few clinicians have published results comparing the three systems.

Presurgical preparation for custom fitted joint prosthesis

Initial pre-surgical workup includes a thorough history and physical including evaluation of range of motion with recording of objective and subjective findings. Use of a standardized examination technique is recommended. If concomitant orthognathic surgery is to be performed, complete maxillary and mandibular impressions with face-bow record, plain films, bite registration, and a dedicated maxillofacial CT scan using a specific scanning protocol (for those cases being planned with virtual surgery) are required. Using the CT data, a 3-dimensional stereolithographic model of the TMJ and associated structures is made using stereolithographic technology. This model can be ordered as a one-piece (if no jaw repositioning is required), or two-piece model (if orthognathic movements are to be performed). For the latter, manually mounting the model on an articulator (Figure 4) is recommended unless computerized virtual planning is to be used. Mock surgery is then performed on the stereolithographic model, which includes removal of the condyle, bony recontouring of the fossa and the ramus components, and correcting the spatial positioning of the mandible (in cases where simultaneous lower jaw repositioning is to be incorporated in the surgical treatment plan). The model is trimmed till the desired anatomy is achieved (Figure 5).

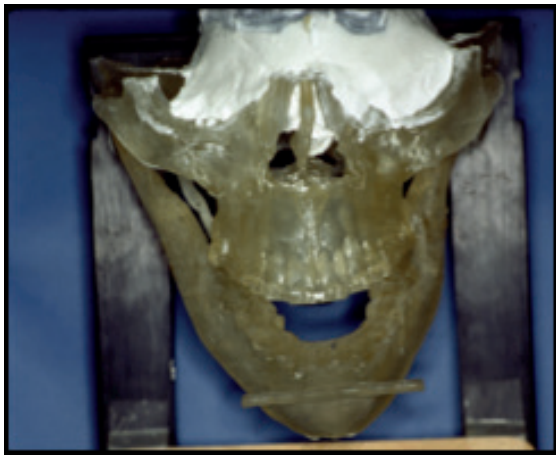


Figure 4. *Stereolithographic model obtained from CT scan data has been mounted on an articulator.*

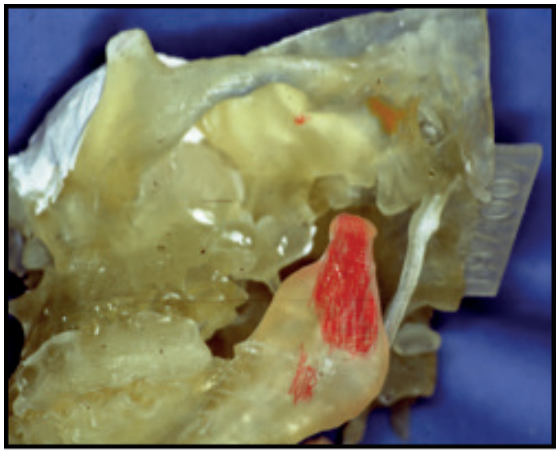


Figure 5. *Condylectomy and recontouring (red markings) of the ramus and fossa completed.*

The surgeon and engineers must inspect the model to ensure that a sufficient gap has been created between the base of the skull and ramus and that sufficient amount of the coronoid process has been removed (if necessary). Any topographical change that is made to the 3-D stereolithographic model must be reproduced by the surgeon during the actual surgical procedure.

Custom-made wax templates are then fabricated by the manufacturer, duplicating the topography of the prosthesis. The fit, anatomy, angulation and placement of screw holes is verified by the surgeon and any changes to the template are returned to the manufacturer for construction of the custom made prosthesis (Figure 6)

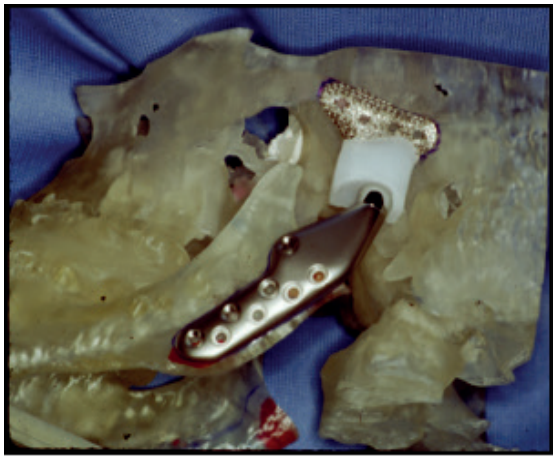


Figure 6. *TMJ Concepts prosthesis (fossa and mandibular components) on the stereolithographic model.*

Some patients who require TMJR also have co-existing mandibular asymmetry, and if this needs to be addressed, the mandible placed in its new position based on the cephalometric surgical treatment objectives; at the final preoperative appointment, standard model surgery is performed, the jaw repositioning movements duplicated, and a surgical splint fabricated (Figure 7).

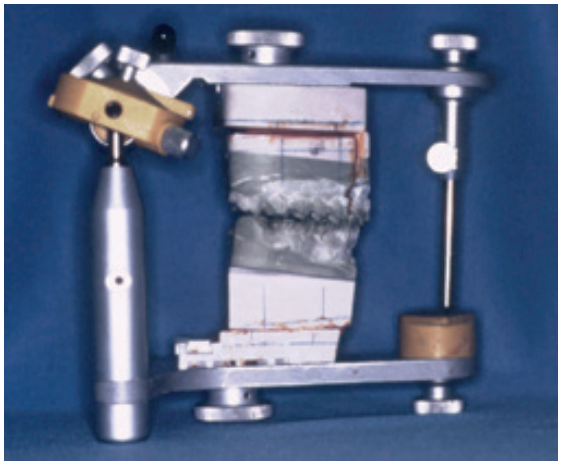
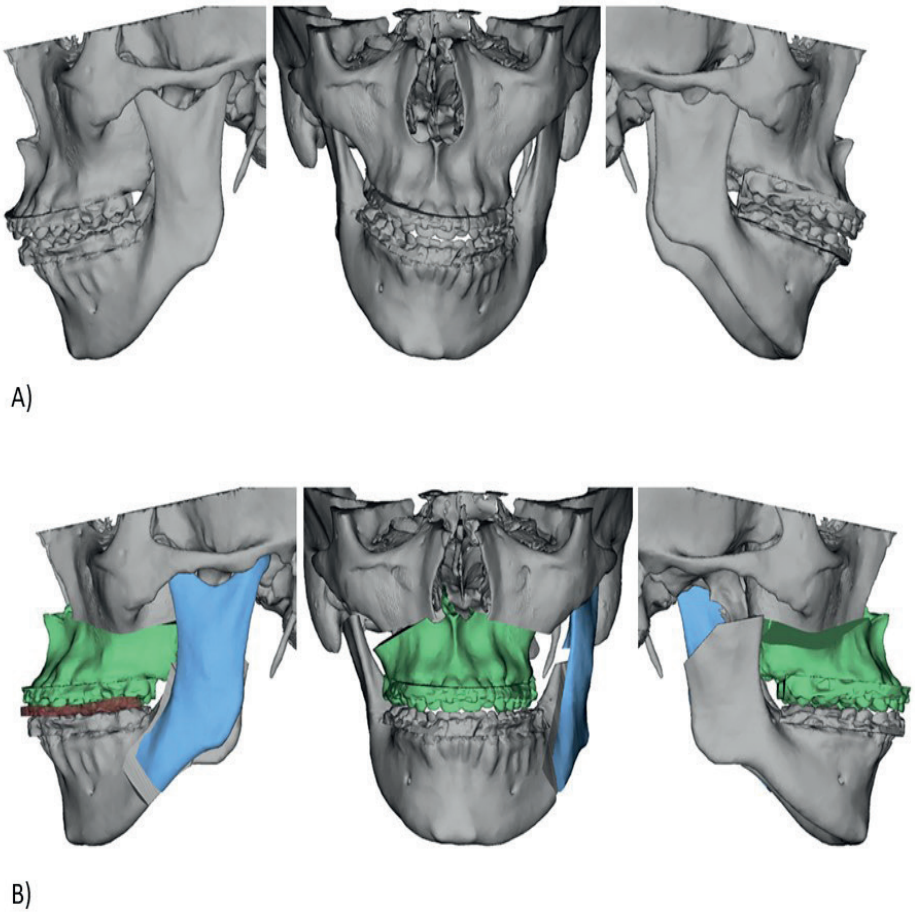


Figure 7. *Standard model surgery for fabrication of occlusal splints.*

Use of cone beam CT scan data, integrated models with occlusion and computer-based virtual surgical planning in the pre-surgical phase (Figure 8a and 8b) can facilitate precision planning and splint fabrication. Use of virtual surgical planning reduces laboratory time by eliminating need for model surgery, increases operator efficiency and accuracy besides aiding in fabrication of better quality splints.



Figures 8. ***(a)*** *Pre-operative 3D reconstruction from the CT scan data demonstrating facial asymmetry, skeletal and dental malocclusion and right TMJ and condylar degeneration.* ***(b)*** *Postoperative occlusion after simulating planned bilateral Lefort 1 osteotomy, left mandibular sagittal split osteotomy and right TMJ condylectomy and total joint replacement.*

Surgical technique

The TMJ is approached via an endaural or pre-auricular incision, and the mandibular ramus is approached via a submandibular incision. Condylectomy, debridement, and bone recontouring are accomplished as previously determined during model surgery. Maxillomandibular fixation with or without a splint in place is then performed. The fossa component of the prosthesis is inserted through the endaural/preauricular incision and is stabilized to the zygomatic arch with three to four 2mm diameter screws. The mandibular component is inserted via the submandibular incision and fixated to the lateral surface of the ramus with eight to ten 2mm diameter screws. Autogenous fat grafts, harvested from the abdomen or buttocks can be packed around the joint prosthesis, if the surgeon desires. Surgical repositioning of the maxilla and other indicated procedures are then performed using standard techniques. At completion of surgery, the intermaxillary fixation is removed and light guiding elastics placed. Active jaw function is encouraged immediately. Most patents do not require formal physical therapy and simple jaw opening and closing type exercises are sufficient. Patients are placed on a soft diet for approximately 4 weeks.

Complications

As with any surgical procedure, there is always an inherent risk of complications, each of which may need to be adequately managed. Adverse outcomes may be related to pre-existing medical conditions, patient compliance, previous surgical history and complexity

of the operation. The most common complications associated with TMJR (besides those common to all TMJ procedures) include the following: Infection, pain/worsening of TMJ symptoms, breakdown and loosening of the prosthesis, facial nerve injuries and metal hypersensitivity.

TMJR associated infections are challenging to treat due to difficulty in diagnosing low grade infections and poor antibiotic availability within the biofilm formation. Infection commonly occurs from skin flora, with oral cavity, nasal cavity, ear canal and hair follicles as possible sites from which contamination may occur. Staphylococcus species are the most commonly associated microorganism with most TMJ surgeons prescribing a week of antibiotics postoperatively (25).

In a review by Wolford *et al.*, postoperative infections involving the TMJ prostheses occurred in 2.5% of the patients and 1.6% of the number of prostheses placed (26). Recently, a ten-year review of TMJ prosthesis demonstrated that 4.5% of the prostheses developed infection (8 out of 178), all necessitating removal despite long term antibiotic therapy (27).

Examination of failed and retrieved TMJR devices revealed significant surface damage between the condylar head and the articulating surface, demonstrating the early role of wear patterns and corrosion interactions (28). If there are clinical signs of infection such as persistent pain, erythema at site, chronic sinus tract or systemic signs, appropriate laboratory tests and radiographic imaging are obtained to establish a diagnosis.

If surgical site infection is confirmed, most patients return to the OR for retrieval of the prosthesis, followed by long-term antibiotics and eventually new prosthesis after infection has resolved. Metal hypersensitivity reactions are rare and most commonly occur to Nickel. Preoperative testing (e.g.: *in vivo* - patch test and *in vitro* -lymphocyte transformation or activation test) in patients undergoing TMJR has been recommended in the literature (12, 29), but this is controversial and results vary.

Case presentation

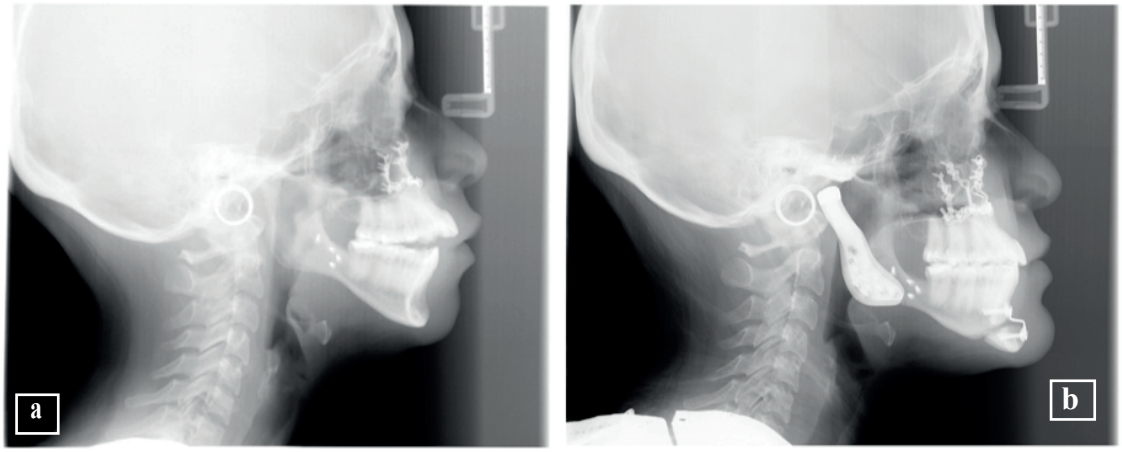
A 23 year-old female presented to our center with TMJ-related complications following orthognathic surgery performed earlier by an outside surgeon. Her postoperative course was complicated by relapse and significant bilateral condylar resorption, with progressive mandibular retrusion. Clinical examination revealed a retrognathic mandible, class II skeletal and dental malocclusion with an anterior open bite (Figures 9a, 10a and 11a). The patient had severe TMJ pain (8/10) and pre-auricular tenderness bilaterally with significant dietary limitations (8/10) and trismus to 16 mm. This patient was treated by a single operation with the following procedures:

1) Bilateral TMJ condylectomy and glenoid fossa debridement.
2) Bilateral TMJ reconstruction with patient-fitted TMJ concepts prosthesis.
3) Mandibular advancement in counterclockwise direction.
4) Lefort 1 osteotomy of maxilla with rigid fixation and bone grafting.6) Bilateral mandibular coronoidectomies.
5) Augmentation genioplasty.

At the 1.5-year postoperative period, patient has no significant TMJ pain (0/10) with maximal inter-incisal opening greater than 35mm, and minimal to no dietary restrictions (0-1/10). The orthognathic movements have been stable (Figure 9b and 10b). She completed orthodontic treatment and has stable and reproducible occlusion (Note: the case was finished by the orthodontist with a crossbite tendency on the right side (Figure 11b) which was planned preoperatively as the patient decided against segmental maxillary surgery in view of her previous complications.)

Conclusion

This review paper focuses on the fundamentals of TMJR for the practicing clinician. An attempt has been made to review pertinent scientific literature and highlight current evidence-based treatment guidelines. Patient-fitted TMJ total joint replacement appears have many benefits over autogenous reconstruction and should be considered as first choice in the management of TMJ patients when joint replacement is indicated. Alloplastic TMJ reconstruction avoids donor site morbidity, decreases operating room time, reduces hospitalization duration, and supports the ability to predictably and concomitantly perform complex orthognathic procedures.



Figures 9. (a) *Preoperative lateral cephalogram showing anterior open bite and failed hardware from previous orthognathic surgery.* ***(b)*** *Postoperative cephalogram.*

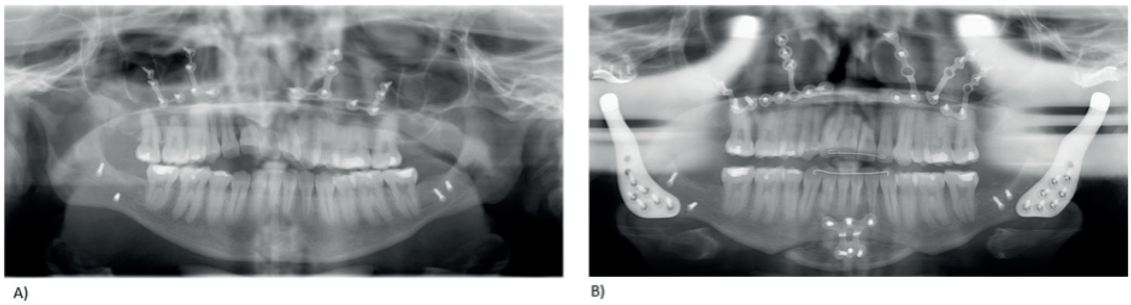
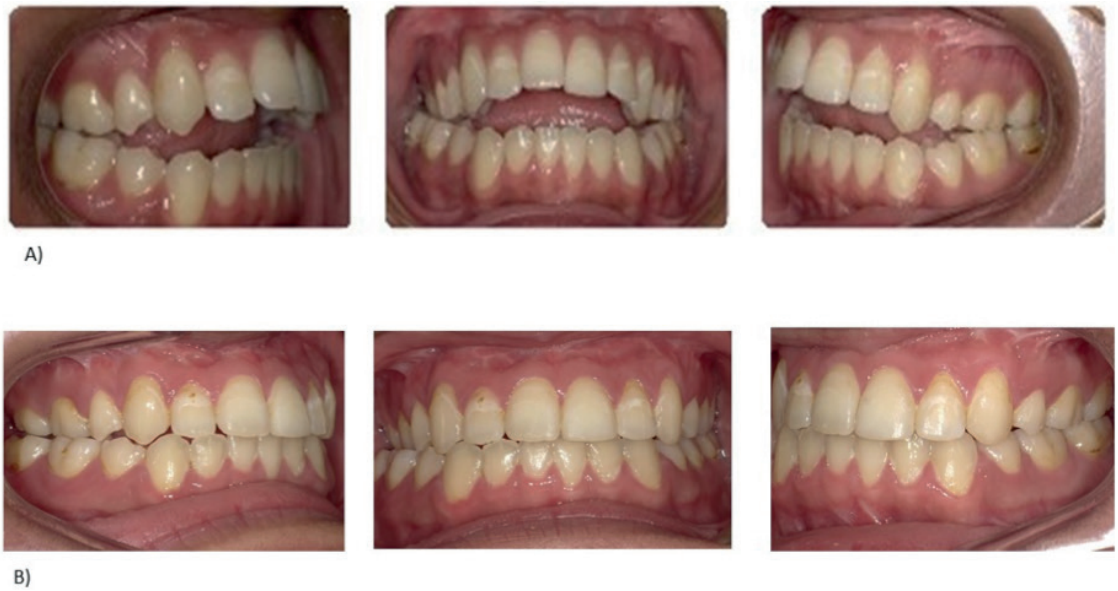


Figure 10*. (a) Preoperative panoramic radiograph showing bilateral condylar head changes and retained bone plates and screws from previous orthognathic surgery.* ***(b)*** *Postoperative panoramic radiograph.*



Figures 11. (a) *Preoperative intraoral photos showing bilateral posterior cross bite and anterior open bite.*
(b) *Postoperative intraoral photos with class I relationship (Note: The patient was offered correction of the cross bite on the right side with segmental maxillary surgery, but she refused.)*

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Conflict of interest
None declared.

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