Autogenous Tissues Versus Alloplastic TMJ Condylar Replacement

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Abstract

End-stage temporomandibular joint (TMJ) disease due to a multitude pathophysiologic process can benefit from TMJ replacement. The traditional method has been used to reconstruct the TMJ using autogenous tissues from various donor sites in the body. However, as materials and understanding how to use those materials have advanced, the pendulum is now moving much more toward alloplastic reconstruction. This chapter will compare and contrast the two types of reconstruction methods for reconstructing the diseased TMJ.

8.1 Introduction

End-stage temporomandibular joint (TMJ) pathology or conditions that may benefit from TMJ condylar replacement include (1) TMJ arthritis with non-salvageable articular discs; (2) advanced stages of adolescent internal condylar resorption (AICR); (3) traumatic injuries; (4) reactive arthritis; (5) osteoarthritis; (6) tumors; (7) absent or deformed anatomical structures resulting in loss of posterior mandibular vertical dimension (i.e., fractured displaced condyles, absence of condyles and portions of the ramus/body as the result of previous trauma, surgery, pathology, or congenital deformity); (8) high or low inflammatory, metabolic arthritic diseases; (9) connective tissue/autoimmune diseases (i.e., rheumatoid arthritis, juvenile idiopathic arthritis, scleroderma, Sjogren's syndrome, lupus, etc.); (10) fibrous or bony ankylosis; (11) multiply operated TMJs (two or more previous surgeries); (12) failed autogenous grafts; (13) failed TMJ alloplastic implants; and (14) other

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end-stage TMJ pathologies. The purpose of this chapter is to describe the various methods of condylar replacement using autogenous tissues or alloplastic total joint replacement and present reports on outcomes of the various techniques.

For many years, the primary method to replace the mandibular condyle when affected by any of the aforementioned conditions and pathologies was to use autogenous tissue grafts. There have been numerous biological structures used for condylar reconstruction, and these include (1) costochondral (rib) graft, (2) sternoclavicular graft (SCG), (3) coronoid graft, (4) chondro-osseous iliac crest graft, (5) vertical ramus osteotomy, (6) distraction osteogenesis, (7) vascularized metatarsal graft, and (8) vascularized fibula graft. There is scant literature on outcome data available to evaluate these various autogenous condylar replacement techniques. Indications of using bone grafting as a condylar replacement include the following: (1) condylar replacement required, (2) pain, (3) zero to one previous TMJ surgeries (for free grafts), (4) good vascular bed (for free grafts), (5) need for hard and soft tissue grafts (vascularized fibula grafts), (6) growth center transplant (rib, SCG), (7) total joint prosthesis unavailable, (8) allergy to metals in total joint prostheses, and (9) patient preference. The types of autogenous grafts used for TMJ condylar replacement and published outcomes will be reviewed.

8.2 Costochondral (Rib) Grafts

Rib grafts are the most common type of autogenous graft used for TMJ condylar replacement (Fig. 8.1). Commonly the sixth or seventh rib is harvested including a section of cartilage attached, with the cartilage portion placed into the fossa and the bone portion on-laid over the lateral aspect of the ramus and stabilized with interosseous wires, bone screws, or bone plate and screws. When the anatomy of the ramus and fossa interrelationship is not compatible with this lateral placement of the rib, then the graft can be placed at the posterior border of the mandible (may require

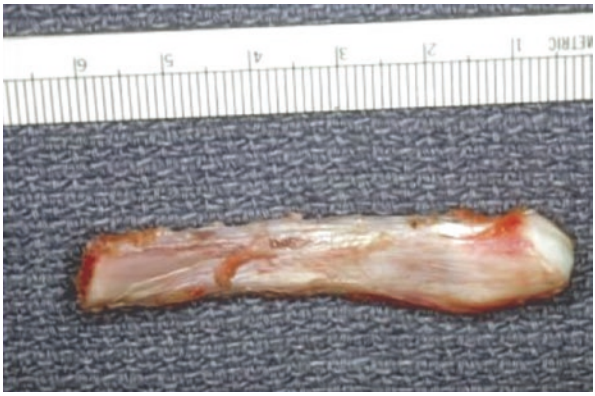

Fig. 8.1 Rib grafts have been the most popular autogenous tissues used for condylar replacement, and the sixth or seventh ribs are the most common area of harvest

removal of a portion of the posterior border of the mandible) or placed on the medial side of the ramus to align with the fossa. In growing patients, growth of the rib may or may not occur. If growth occurs, it is often excessive as the graft grows like a rib, not like a mandibular condyle. This causes the ipsilateral mandible to overgrow, shifting the mandible toward the contralateral side or vertically elongating the ipsilateral side (vector of growth dependent on orientation of graft placement) requiring further surgery (Fig. 8.2a–d). When the graft does not grow, there will be a resulting underdevelopment of the ipsilateral side of the mandible. With excessive overgrowth, further surgery may be required to remove the growth center which is at the epiphyseal center of the rib graft and, as with deficient growth, may require orthognathic surgery after cessation of normal growth to optimize jaw function and esthetics.

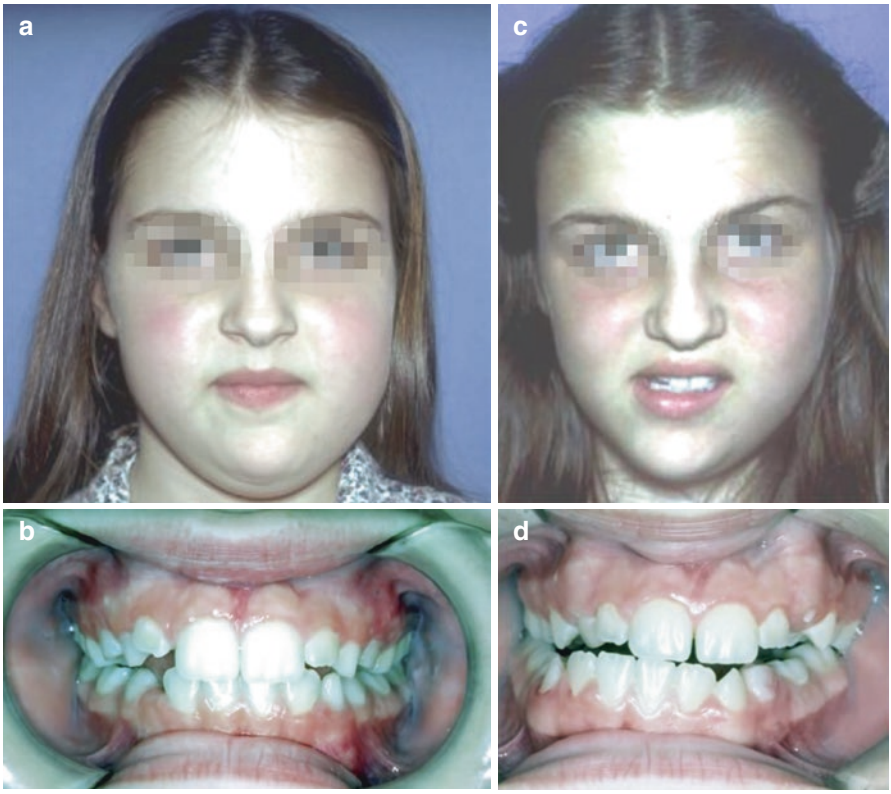

Fig. 8.2 (**a**) A 12-year-old female with a left-sided bony ankylosis. The patient is seen here immediate post rib graft to replace the left mandibular condyle. (**b**) Immediate postsurgical occlusion shows that the dental midlines are congruent. (**c**) Eighteen months post surgery, a significant facial asymmetry is noted related to the overgrowth of the left costochondral graft. (**d**) A significant change in the occlusion is noted with the mandibular dental midline shifted approximately 8 mm toward the right side and the left occlusion developing into a Class III occlusion illustrating significant overgrowth of the left mandibular costochondral graft

In cases of ankylosis treated with rib grafts, the risk of re-ankylosis is high, particularly in growing patients. In the presence of reactive arthritis and connective tissue/autoimmune diseases, rib grafts are susceptible to the same diseases that created the TMJ pathology that required the condylar reconstruction in the first place. The overall failure rate of rib grafts is high. Donor site complications can include pleural tear and effusions, pneumothorax, hemothorax, atelectasis, pneumonia, intercostal nerve injury, etc. At the joint American Society of TMJ Surgeons (ASTMJS) and the European Society of TMJ Surgeons (ESTMJS) held in Lille, France, May 18–20, 2017, there was a strong consensus that alloplastic total joint prostheses outcomes were far superior to rib grafts. Rib grafts were only recommended when alloplastic total joint prostheses were not available or the patient had hypersensitivity to the metals in the prosthesis.

There are a few studies in the literature purporting the efficacy of rib grafts. Perrott, Umeda, and Kaban [1] published a study on 26 patients, 33 grafts, 7 of the patients growing, and average follow-up was 48 months. The incisal opening improved from a range of 10–46 mm to a range of 27–51 mm. The authors state that the disc was maintained in ten cases, and in the others temporalis muscle flaps were performed. The authors reported good results. Maintaining the articular disc or placing an inter-positional soft tissue graft between the fossa and graft may improve the outcomes.

Saeed et al. [2] published a study on 57 patients utilizing 76 costochondral grafts with a minimum follow-up of 2 years. The incisal opening improved from 21 to 24 mm. Pain improved from 6.7 to 3.5 (0 = no pain, 10 = worst pain), but the diet worsened from 2.2 to 3.0 (0 = no restrictions, 10 = liquid only). Previous failed alloplastic implants and ankylosis produced a significantly higher complication rate and a significant increase in additional surgery where over 50% of the patients that received costochondral grafts required additional surgery.

Troulis et al. [3] reported on 15 patients with idiopathic condylar resorption receiving costochondral grafts. The mean age was 24 years. The patients all had Class II occlusions with anterior open bites. The average follow-up was 34 months, range 12–84 months. Incisal opening at longest follow-up was 39 mm. The authors reported stable Class I occlusions with no open bite redevelopment.

Advantages:

1. Native tissue
2. Growth potential
3. Relatively easy to harvest
4. Fits well into the fossa with proper orientation of the graft although ramus modification may be required

Disadvantages:

1. Can correct a mild to moderate dentofacial deformity but may be difficult to maintain a stable skeletal and occlusal result.
2. Graft weak, flexible and elastic, subject to deformation and fracture.

3. Cortical bone may be very thin and medullary bone exhibits light density.
4. Subject to physiological loading and adaptations.
5. Growth unpredictable.
6. High recurrence rate when used for TMJ ankylosis.
7. Risk of donor site complications such as pneumothorax, plueral effusion, hemothorax, intercostal nerve injury, esthetic defect.

8.3 Sternoclavicular Grafts (SCG)

Sternoclavicular grafts (SCG) are probably the most ideal autogenous free grafts for TMJ condylar replacement. Development and growth of the sternoclavicular joint are the most similar to the TMJ than any other joint or potential graft system in the body. There is an articular disc present that can also be harvested. Usually the upper half of the clavicle is harvested with half of the articular disc (Fig. 8.3). The cortical bone is quite thick and strong, filled with lots of medullary bone. The thick cortical bone requires placement of multiple holes to aid in revascularization (Fig. 8.4a, b). The SCG adapts well to the fossa if it is rotated 90° and placed along the posterior border of the mandible (may require partial resection of the posterior border for best adaptation into the fossa and bony interface with the ramus). It can be attached to the mandible with bone plates (Fig. 8.4c). The donor site is quite weak as a result of the harvest and susceptible to fracture. Figure-of-eight bandage and arm sling are required to decrease the risk. Clavicular fracture may require bone plate stabilization. Although significant dentofacial deformities can be corrected by advancing the mandible with SCGs, physiological loading and associated effects on this biological tissue may cause some bony adaptation resulting in difficulty controlling the skeletal and occlusal relationship (Figs. 8.5, 8.6, and 8.7).

Wolford et al. [4] in 1994 published a study on 38 patients receiving 52 SCGs with a mean age of 25.9 years with a mean follow-up of 45 months. Success was determined by decrease in pain, stable occlusal outcome, and incisal opening greater than 30 mm. The patients were divided into three groups. Group 1 composed of 14

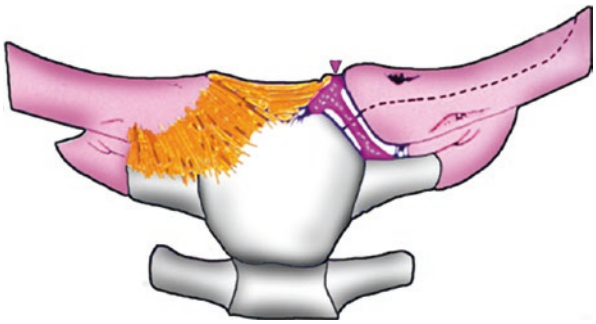

Fig. 8.3 In procuring a sternoclavicular graft, usually the upper half of the clavicle including the adjacent articular disc is harvested

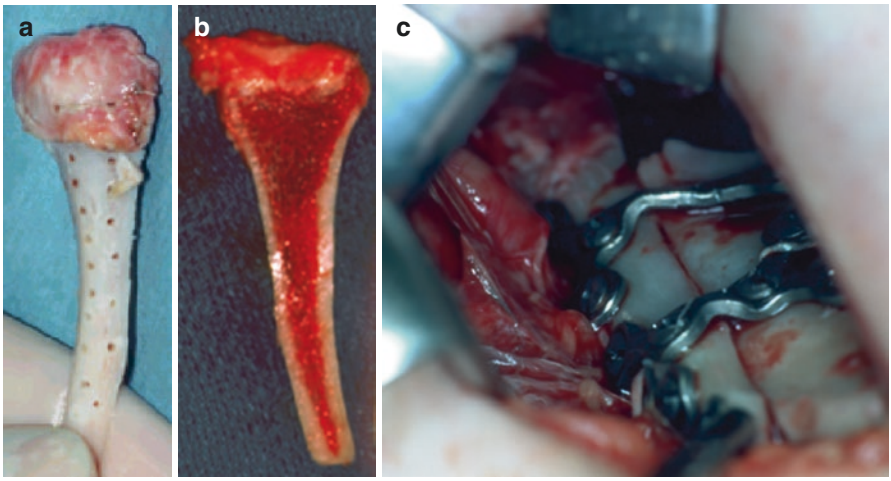

Fig. 8.4 (**a**) A harvested sternoclavicular graft is prepared. The cortical bone is quite thick so placing multiple interosseous holes helps with revascularization. (**b**) Shows the thickness of the cortical bone but also the plentiful medullary bone present in this graft. At the top of the condyle, the articular eminence is noted. (**c**) Sternoclavicular graft is placed against the modified posterior border of the right mandibular ramus and stabilized in position with bone plates. Notice a nice adaptation of the graft to the posterior border of the mandible

patients that had received previous Proplast Teflon TMJ devices (Vitek Inc., Houston, TX, USA) as inter-positional implants or total joint prostheses. Although the joints were thoroughly debrided at the time of placement of the sternoclavicular grafts, the success rate was only 29%. The high failure rate was related to the foreign body giant cell reaction that developed in these joints with these failed alloplastic materials. Although the joints were thoroughly debrided, it is impossible to remove all this material, and the foreign body giant cell reaction can be reinitiated, thus, affecting the outcomes of autogenous joint reconstruction. Group 2 consisted of patients with inflammatory disease processes such as reactive arthritis and connective tissue autoimmune disease such as rheumatoid arthritis, psoriatic arthritis, juvenile idiopathic arthritis, etc., and consisted of ten patients. In this group, the success rate was only 50% as a result that disease processes will attack autogenous tissues put into joint areas. Group 3 consisted of patients who had no previous alloplastic implants and no inflammatory process, and in most all of the patients, this was their first operation with 14 patients included in this group. The success rate was 93%, showing that this graft protocol worked well when there was no previous failed alloplastic implants, inflammatory disease issues, connective tissue/autoimmune diseases, and particularly when performed as the first operation.

The SCG was harvested from the superior half of the clavicle including the associate articular disc. This graft was then inserted into the TMJ area generally posterior to the mandibular ramus and rotated 90° to fit into the fossa, or in cases such as hemifacial microsomia, the SCG was placed on the medial side of the ramus with the condyle positioned against the skull base. Because the graft consisted of the

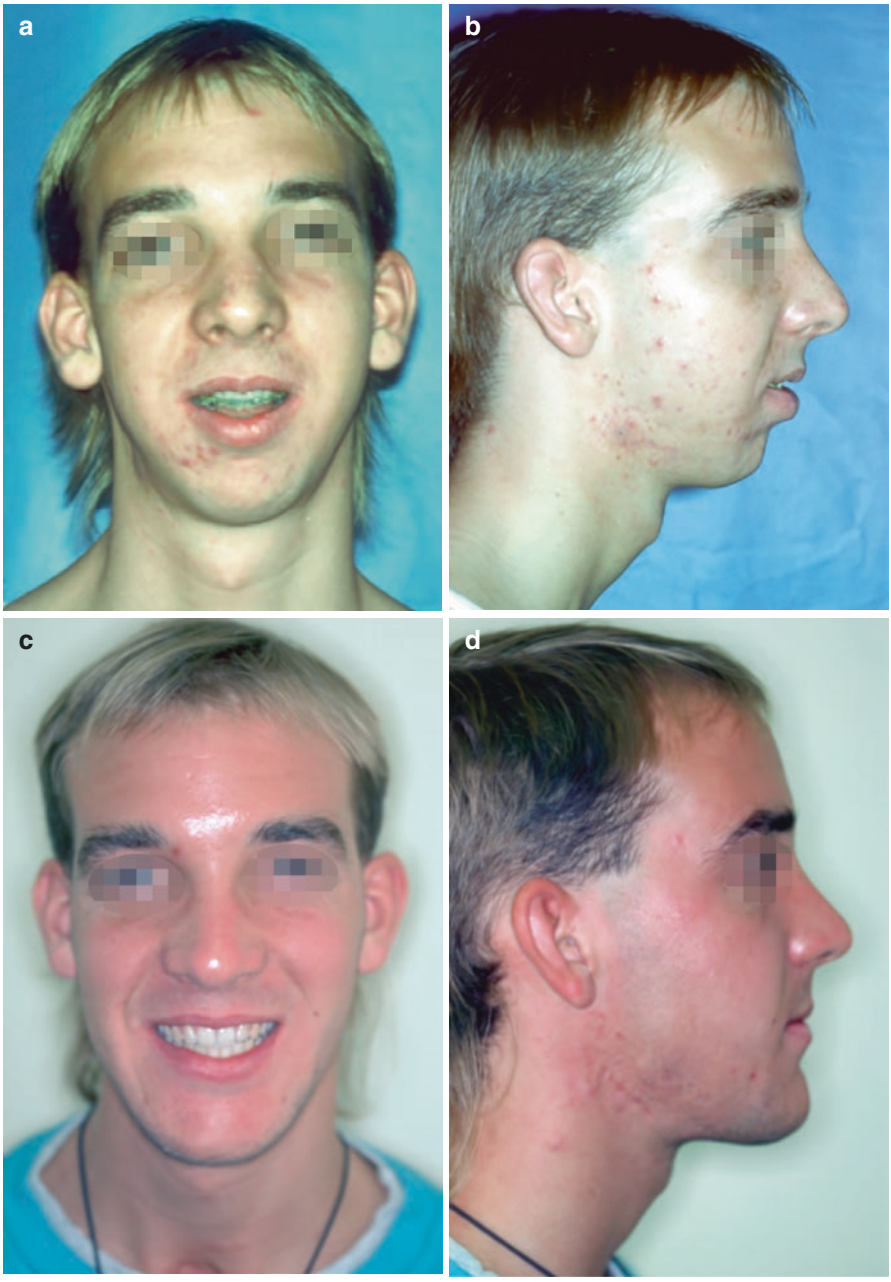

Fig. 8.5 (**a**) A 19-year-old male with juvenile idiopathic arthritis resulting in severe condylar resorption, a retruded mandible, and anterior open bite. (**b**) Profile view shows the retrusion of the maxilla and mandible. (**c**) The patient seen 2 years post surgery showing improved appearance from the frontal view. (**d**) Illustrates the 2-year post surgery profile. Pogonion was advanced forward a total of 34 mm

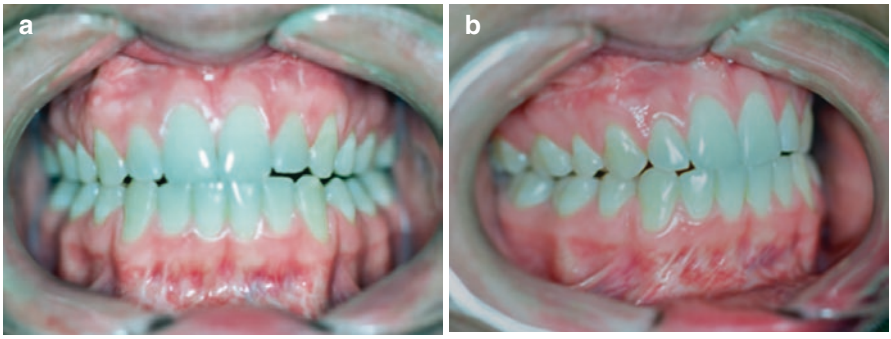

Fig. 8.6 (**a, b**) Occlusion at 2 years post surgery noting the mid-buccal open bite tendency. Using autogenous grafts for mandibular advancement can create significant issues with maintaining an ideal occlusion as the grafts are subject to physiological changes from stresses placed on the graft with significant advancements. Lateral view shows the bite is slightly open in the mid-buccal segments

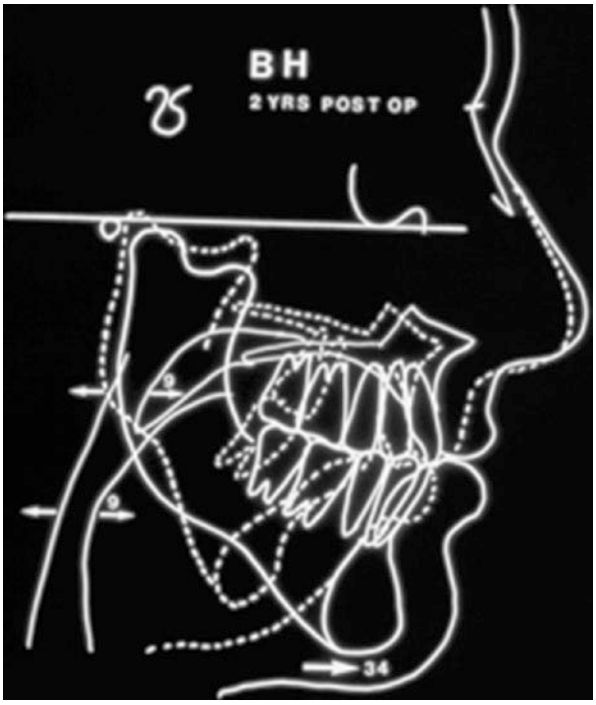

Fig. 8.7 Pre- and post surgery cephalometric super-imposition. The dotted line illustrates the presurgical cephalometric tracing, while the solid line represents 2 years post surgery illustrating the significant changes that can be accomplished with these autogenous sternoclavicular grafts

upper half of the clavicle, this severely weakened the remaining clavicle. Although patients were placed in figure-of-eight supportive bandages and arm slings to reduce loading of the clavicle, there were still five fractured clavicles (10%) that occurred post surgery.

Singh et al. [5] published a study on 15 patients with unilateral TMJ ankylosis and had 15 joints reconstructed with sternoclavicular grafts. Age range was 10–18 years with a mean follow-up of 27.4 months. Incisal opening had an initial range of 0–5 mm, and immediately post surgery, the incisal opening was 34.9 mm. The authors reported that there was no change in this opening long term. One case was classified as a failure. Donor site morbidity included two fractured clavicles (13%).

Advantages:
1. Native tissue
2. Growth potential more consistent of a growth rate similar to the TMJ condyle
3. Strong cortex
4. Significant amount of medullary bone
5. Fits well into the fossa with proper orientation of the graft
6. Articular disc present

Disadvantages:
1. Can correct a significant dentofacial deformity but may be difficult to maintain a stable skeletal and occlusal result
2. Subject to physiological loading and adaptations
3. Risk of donor site fracture

8.4 Coronoid Grafts

There have been two methods for condylar replacement using the coronoid process: a free graft and a pedicled graft. For the free graft, the coronoid process is harvested, and the tip of the coronoid is placed in the fossa to function as the point of articulation and then attached to the ramus via interosseous wires, bone screws, or bone plates. The pedicled graft keeps the temporalis muscle attached to the coronoid as it is positioned in the fossa and stabilized in the same manner as the free graft. The coronoid graft has a very narrow and small articulating surface that may cause some issues post surgery, such as perforation of the disc or any other soft tissue graft to replace the disc. A couple studies have evaluated the outcomes of these techniques.

Zhu et al. [6] reported using free coronoid grafts to reconstruct the TMJs in 15 patients with TMJ ankylosis. Follow-up average was 22 months. The authors state that the native discs or temporal muscle flap was used to provide tissue between the

grafted coronoid section and the fossa. The authors report satisfactory results. All cases exhibited bone resorption of the grafts, but the authors stated there were no occlusal changes.

Liu et al. [7] reported on the use of a pedicled coronoid graft to reconstruct the TMJ in 24 patients and 28 joints. A temporal muscle flap was placed in the glenoid fossa. This study compared free grafts with pedicle grafts, and it was noted there was more bone resorption in the free grafts, and there was a better overall outcome using the pedicle grafts.

Advantages:
1. Native local tissue
2. Can be pedicled to help eliminate vascular compromise and bone resorption

Disadvantages:
1. Narrow-pointed functional head
2. No growth potential
3. Cannot correct even mild dentofacial deformity
4. Subject to physiological loading and adaptation

8.5 Chondro-Osseous Iliac Crest Graft

This little used technique involves harvesting a graft from the iliac crest including the cartilage surface and underlying bone. The graft is inserted into the fossa and secured to the ramus.

Kummoona [8] used a chondro-osseous iliac crest graft in six children with TMJ ankylosis with a mean follow-up of 18 months. The incisal opening improved from a range of 0–5 mm to 34–43 mm. The authors reported growth was seen in all cases with full functional activity with protrusion. There was no recurrence of ankylosis reported.

Advantages:
1. Native tissue
2. Claimed growth potential

Disadvantages:
1. Requires harvesting of the graft.
2. Difficult to control growth vector.
3. Cannot predictably correct dentofacial deformity.
4. Subject to physiological loading and adaptation.
5. Only six patients had been reported in the literature that received this procedure.

8.6 Vertical Ramus Osteotomy

Following the performance of a condylectomy, the TMJ can be reconstructed by doing a vertical ramus osteotomy and reposition the proximal segment superiorly into the fossa and apply rigid fixation. There is very little data in the literature supporting this technique.

Liu et al. [9] published a study involving 18 patients and 21 ankylosed joints with a 36-month follow-up. The authors state they either maintained the native disc or performed a temporal fascia muscle flap to place into the joint area. The mean incisal opening was improved from 5 to 36 mm with no re-ankylosis.

8.7 Distraction Osteogenesis

Although distraction osteogenesis has been used to lengthen the mandible and sometimes the maxilla, its application for replacement of the TMJ condyle has received little attention. The technique involves performing an osteotomy involving the posterior border of the ramus and applying a distractor device and following distraction protocol. The design of the operation includes performing the condylectomy followed by an osteotomy in the posterior ramus of the mandible, preserving the angle of the mandible, but performing a reverse L-type bone cut and adapting the distraction device. Post surgery after a latent period, the device is activated, displacing the new neo-condyle superiorly up toward the fossa area.

Schwartz and Relle [10] reported on 12 patients and 13 joints, with a follow-up of 7–56 months. They used inter-positional fat grafts or temporal fascia muscle flap within the joint area. Incisal opening presurgery had a range of 3–46 mm and final outcome ranged from 20 to 53 mm. Most patients were reportedly asymptomatic at longest follow-up. One bilateral rheumatoid arthritis patients had postoperative condylar resorption and relapsed.

Cheung and Lo [11] presented five unilateral ankylosed patients with five treated joints by distraction osteogenesis with an age range of 3–51 years and a follow-up of 1–2 years. Latency period was 7 days. Total activation was 8–19 mm. Incisal opening improved from an average of 14 to 38 mm at longest follow-up. The mean satisfaction score was 8.6 out of 10.

Advantages:

1. Native tissue.
2. No bone harvest required.
3. With careful surgery, the graft can remain pedicled to help with vascular viability.

Disadvantages:

1. Requires two operations: One to place the distraction device and a second procedure to remove it.

2. Difficult to control the vector of distraction.
3. Cannot correct a major dentofacial deformity.
4. Narrow mediolateral width of the neo-condyle.
5. Long treatment time.
6. Subject to physiologic loading and adaptations.

8.8 Vascularized Metatarsal Graft

This technique involves harvesting the second metatarsal (toe) including the distal joint and associated vessels providing the vascularity. The graft is transplanted to the TMJ and anastomosed to the temporal vessels or other vasculature in the area. The graft can be positioned so that the distal metatarsal joint functions as the new TMJ. This allows only hinge movement of the new joint. There are three studies in the literature using this technique.

Landa et al. [12] reported on four patients with five joints reconstructed with a vascularized metatarsal graft. Mean age of 29 years with a range of 17–45 years. Median length of operation was 6.5 h with a mean follow-up of 12.5 years. Incisal opening presurgery was 12 mm and at longest follow-up had a mean of 48.5 mm. The function was rated as acceptable.

Potter and Dierks [13] reported on 9 patients and 11 joints with 2 patients being bilateral. They reported good results in the use of this vascularized grafting system to reconstruct the TMJ (see Chap. 10).

Bunke et al. [14] reported that non-vascularized metatarsal grafts had severe degenerative changes and re-ankylosis, whereas the vascularized metatarsal grafts had much better outcomes.

Advantages:
1. Native tissue
2. Vascularized graft
3. Good fit in the fossa
4. Works well in areas where there is decreased vascularization

Disadvantages:
1. Creates a significant foot deformity
2. Cannot correct large dentofacial deformities
3. Cannot reconstruct large mandibular defects
4. Subject to physiological loading and adaptations

8.9 Vascularized Fibula Grafts

The vascularized fibula graft for TMJ reconstruction is more appropriate when there is an associated large mandibular bone defect involving the condyle, ramus, and body. These are long involved operations, often requiring two surgical teams, with

extended hospital stays and increased expenses. This technique should be reserved for the large defects where bone is required for reconstruction, bone and soft tissue required for reconstruction, vascular compromise in the surgical area, and irradiated tissue (see Chap. 10, and for an alternative approach in osteoradionecrosis patients, see Chap. 11).

Gonzalez-Garcia [15] reported on six patients receiving a vascularized fibula graft to reconstruct the TMJ. The author states that the articular discs were preserved and placed on the graft head. The author reported results that five of the patients had adequate function, but one patient ankylosed.

Guyot et al. [16] reported on 11 patients with 11 joints treated with vascularized fibula grafts. The age range was from 17 to 36 years with a follow-up of 12 to 60 months. The authors state that the articular disc was maintained in the joint. The neo-condyle was rounded off and narrowed to better fit within the glenoid fossa. Incisal opening reported changed from 33 to 34.6 mm.

Wax et al. [17] reported on 17 patients with 13 radiation treatments with a mean age of 62 years. Hospital stay was 11.6 days. Outcome data showed 10 patients could chew a regular diet, 7 a soft diet, 4 full liquid, and 4 remaining on tube feedings.

Advantages:
1. Native tissue
2. Vascularized graft
3. Good in vascular compromised areas
4. Can reconstruct large mandibular defects with both hard and soft tissues

Disadvantages:
1. Unsightly donor site scar
2. Long procedure
3. Increased costs and hospitalization time
4. Requires two surgical teams
5. Graft subject to physiological loading and adaptations

8.10 Contraindications for Free Autogenous TMJ Condylar Replacements

The contraindications to using free bone grafts for TMJ reconstruction include the following: (1) multiply operated TMJs (two or more previous TMJ procedures), (2) connective tissue autoimmune disease and inflammatory diseases, (3) previously failed TMJ alloplastic implant or prosthesis, (4) conditions causing decreased vascularization and prolonged healing, (5) patient with polyarthropathies, and (6) requirement of concomitant TMJ and orthognathic surgery to reconstruct the TMJs and associated dentofacial deformity.

8.11 Common Complications with Autogenous Grafting for Condylar Replacement

There are numerous complications that can occur with the harvesting and grafting of autogenous tissues used for TMJ condylar reconstruction. This includes, but not limited to, (1) excessive growth (rib grafts) or no growth, (2) donor site complications, (3) improper position/fit of graft, (4) supporting hardware failure, (5) fracture or failure of the graft, (6) avascular necrosis. (7). heterotopic bone/fibrosis resulting in ankylosis, (8) adverse physiological effect (warpage, resorption, fracture), (9) infection, (10) CN V and VII nerve injuries, (11) skeletal relapse and malocclusion, and (12) requirement for additional surgical procedures.

8.12 Condylar Replacement with Total Joint Prostheses

There are two basic types of TMJ prostheses: stock (off-the-shelf devices) and patient-fitted systems. Components of the stock prostheses come in various sizes and shapes so that the surgeon then selects the fossa and mandibular components that best fit the presenting anatomy. This approach does not require significant presurgical preparation, may require significant intraoperative bony preparation, but does require an inventory of "parts" for selection. The patient-fitted devices are custom-designed to fit the patient's specific anatomical requirements providing a good fit of the components to the anatomical structures. However, this method requires presurgical preparation that may include TMJ and orthognathic surgical planning, virtual surgical planning (VSP), printing of a 3D stereolithic model, and surgical simulated preparation of the 3D model on which the patient-fitted prostheses will be manufactured. The presurgical time commitment for preparation is much greater compared to the stock prostheses, but the fit of the components is superior. These two types of prostheses, indications, advantages and disadvantages of each system and the outcome literature available for these devices will be presented.

The aforementioned TMJ pathologies and conditions can significantly alter the anatomy in the TMJ area and mandible resulting in an associated dentofacial deformity, malocclusion, functional impairment, airway obstruction, and pain. Mandibular advancement and/or counterclockwise rotation (rotating the anterior aspect of the maxillomandibular complex upward and/or the posterior aspect downward) may be necessary to correct such deformities in order to achieve an optimal functional and esthetic result. These repositioning movements can create a large gap between the fossa and mandibular ramus/condyle structures. In these circumstances as well as those with altered anatomy from the TMJ pathology, a patient-fitted total joint prosthesis can provide accurate adaptation of a TMJ TJR device to the anatomical structures for each individual patient.

There are three TMJ total joint prostheses currently available in the US market. These are manufactured by the following three companies: (1) Nexus CMF (Salt Lake City, UT, USA), the devices were previously manufactured by TMJ Implants Inc., (Golden, CO, USA) and commonly referred to as the "Christensen"

prostheses; (2) Biomet Microfixation (Jacksonville, FL, USA); and (3) TMJ Concepts Inc. (Ventura, CA, USA). These three devices will be independently presented including composition, presurgical and intraoperative preparation, published outcome data, as well as the advantages and disadvantages of each system.

8.13 Nexus CMF (Christensen) TMJ Replacement System

The Nexus CMF (Christensen) TMJ replacement system is a stock (off the shelf) device, although patient-fitted devices are available. The ramus and condylar head of the mandibular component are composed of chromium cobalt alloy with vertical lengths of 45, 50, and 55 mm. The fossa component is a chromium cobalt alloy with 44 different configurations. Surgeon must pick the fossa and mandibular components that best fit the anatomical configuration of the patient's fossa and mandibular ramus. This device is a metal-on-metal articulation (Fig. 8.8). Screws are made of chromium cobalt alloy and are 2.7 mm diameter for the mandibular component and 2 mm in diameter for the fossa component. There is no stable posterior stop on the fossa.

Chase et al. [18] in 1995 presented data of 21 patients with 34 joints. The authors reported a 95% decrease in pain, 86% increase in ability to eat, and 91% increase in

Fig. 8.8 The Nexus CMF (Christensen) prostheses have a metal-on-metal articulation. There are numerous fossa designs (approximately 40) and three mandibular components of different sizes to choose from

incisal opening. The second study on the Nexus CMF website [19] in 2014 presented outcomes on 42 patients, although the number of joints was not included. Follow-up was 36 months, and genders were also not identified. This was a mixed sample with 18 patients with total joint prostheses and 24 patients who received just the fossa implant only. This study stated a pain reduction from 8.0 to 2.7 on a 0–10 scale (0 = no pain, 10 = worst pain). Incisal opening in the 18 total joint prostheses patients improved from 10.8 to 31.0 mm.

Wolford et al. [20, 21] evaluated 76 joints that received Christensen total joint prostheses with metal-on-metal articulation, with the average patient follow-up of 31.2 months. MIO increased by 3.5 mm (23.6–27.1 mm), and the jaw function improved by 1.9 levels (7.7–5.8), where 0 = normal jaw function and 10 = no jaw function. There was a statistically significant improvement for MIO and patient perception of jaw function. There were 25 Christensen prostheses (33%) removed because of elevated pain levels due to device failure (Fig. 8.9) and/or metal hypersensitivity due to metallosis.

Advantages of the Nexus system:

1. Off-the-shelf product, ready for immediate use.
2. Patient-fitted devices are available.
3. 44 fossa and three mandibular component configurations to choose from for best fit of the stock prosthesis.
4. No presurgical preparation.

Disadvantages of the Nexus system:

1. Metal-on-metal articulation can cause metallosis, and fracture of the fossa component can occur. Metal-on-metal articulating devices have been removed from the market in orthopedic surgery.
2. Requires large inventory of parts.

Fig. 8.9 Potential complications of these devices are metallosis and fracture of the fossa component

3. Inadequate posterior stop in the fossa component that may limit potential to advance and vertically lengthen the mandible.
4. Not indicated for patients who have significantly altered TMJ and mandibular anatomy.

8.14 Biomet Microfixation TMJ Replacement System

The Biomet Microfixation TMJ replacement system is a stock device (off the shelf) with fossa and mandibular components to choose from. Patient-fitted devices are available, but not in the USA. Clinical trials for the stock device were initiated in 1995 and granted FDA approval in 2005. The ramus component is composed of a chromium cobalt alloy, but the ramus side has a titanium coating to help with osseointegration. The ramus component is available in three lengths: 45, 50, and 55 mm. There are three basic styles including standard, offset, and narrow. The fossa is composed of ultrahigh molecular weight polyethylene, and there are three fossa sizes to choose from including small, medium, and large. This is metal-on-polyethylene articulation, which is the gold standard in orthopedics (Fig. 8.10a, b). The mandibular component is stabilized to the ramus with 2.7 mm diameter screws, and the fossa component is secured to the lateral rim of the fossa with 2.0 mm diameter screws.

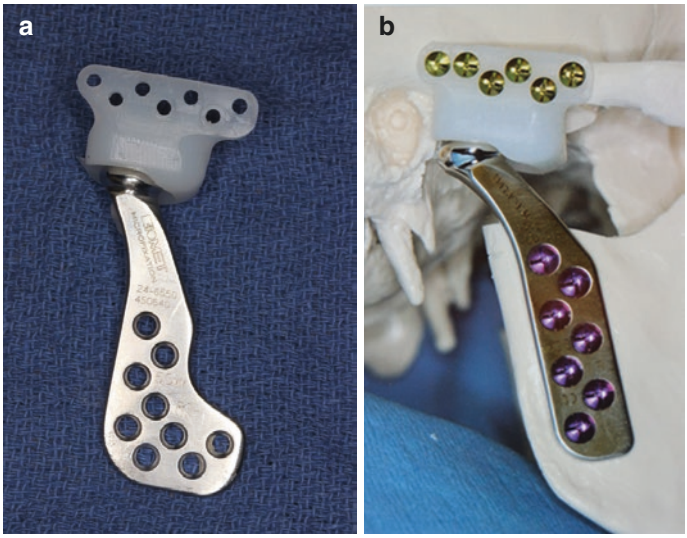

Fig. 8.10 (**a**) The Biomet micro fixation standard prosthesis is composed of a polyethylene fossa component and a chromium cobalt alloy mandibular component. The mandibular component comes in three lengths and also comes with an offset of the condylar head. (**b**) Demonstrates the "narrow" mandibular component of the Biomet system

Giannakopoulos [22] reported on 204 patients with a 3-year follow-up following the placement of the devices. The mean age was 41 years and 89% were female. The mean number of prior surgeries was 4.9 per joint. Presurgery pain was at 8.0 and decreased to 2.6 long term. Jaw function improved from 8.2 to 2.5. Maximum incisal opening improved from 20.4 to 29.5 mm. 3.2% of the implants were removed. Machon et al. [23] presented a European multi-institutional study with 27 patients and 38 joints with an average of 24 months follow-up. Four of the patients had custom-made devices, and the others were stock devices. There were 21 females with a mean age of 42.6 years. Incisal opening improved from 17.7 to 29.1 mm. Relative to pain, 15 patients improved from 4 to 2 (0–5 scale), 4 patients developed worse pain, and 8 patients had no pre- or postoperative pain.

Aagaard et al. [24] reported on 61 patients using the custom-made Biomet prosthesis with a mean follow-up of 14 months. There was significant improvement in incisal opening at longest follow-up, and there was significant decrease in pain. Approximately 19% of the prostheses were associated with complications. Leanardo et al. [25] reported outcomes on 300 patients (201 unilateral and 99 bilateral) with a mean follow-up of 3.5 years. Incisal opening, function, speech, and diet showed improvement over 3 years. Pain improved, and no patients reported severe pain at 6 months post surgery. Dimitroulis [26] reported a study for end-stage TMJ disease comparing three groups: condylectomy only, rib grafts, and Biomet stock prostheses. Condylectomies resulted in best range of motion, and rib grafts experienced the greatest number of complications requiring reoperation (44% of cases). The prosthesis group had the best mean aggregate score on quality of life, but was not statistically significant. Range of motion of the prosthetic patients was no better than the rib graft patients.

Westermark [27] reported on 12 patients (5 unilateral and 7 bilateral) receiving Biomet prostheses with follow-up of 2–8 years. Ankylosed patients' incisal opening improved to 30 mm, and the other patients maintained an opening of more than 35 mm. The author states that joint-related pain and interference with eating were eliminated. Sanovich et al. [28] reported on 36 patients (26 bilateral and 10 unilateral) receiving Biomet stock prostheses with a follow-up of 6–83 months. Incisal opening improved from 26 to 34.4 mm. Pain scores decreased from 7.9 to 3.8, diet improved from 6.8 to 3.5, and quality of life improved from 4 to 2. Four implants required removal.

Advantages of the Biomet system:

1. Off-the-shelf device, ready for immediate use.
2. Metal-on-polyethylene articulation; the gold standard in orthopedics.
3. Patient-fitted devices are available outside the USA.
4. Osseointegration of the mandibular component occurs.
5. No presurgical preparation required.

Disadvantages of the Biomet System:

1. Requires recontouring of the fossa and perhaps the ramus to achieve fit of the stock components.
2. No osseointegration of the fossa component.

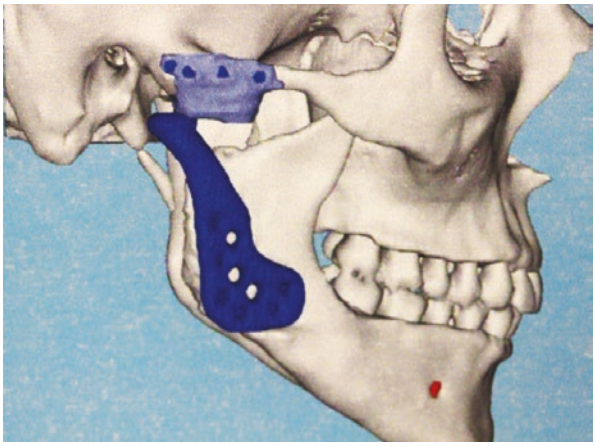

Fig. 8.11 Since the fossa component has no posterior stop, a complication can include posterior displacement of the mandibular component relative to the fossa

3. No posterior stop on the fossa component, which limits ability to advance the mandible and vertically lengthen the ramus and increases risk for posterior dislocation of the mandibular component (Fig. 8.11).
4. Stock prosthesis not indicated for patients who have significantly altered TMJ and mandibular anatomy.

8.15 TMJ Concepts Total Joint Prostheses System

The TMJ Concepts patient-fitted devices were originally developed in 1989 by Techmedica (Camarillo, CA, USA) and manufactured until July 1993 when the US Food and Drug Administration (FDA) halted production of all TMJ devices developed after 1976 [29]. In 1996, the FDA permitted the new owners, TMJ Concepts (Ventura, CA, USA), to manufacture the device under the 510 K provision and granted full approval of these Class III devices in 1999. The TMJ Concepts devices are computer-assisted designed/computer-assisted manufactured (CAD/CAM) devices, designed and manufactured to fit the specific anatomical, functional, and esthetic requirements of each specific patient. The fossa component is made of a titanium shell with a mesh covering all surfaces and ultrahigh molecular weight polyethylene attached to the undersurface for articulation with the condylar component. The mesh on the titanium shell that is patient-fitted to the patient's fossa and lateral rim of the fossa anatomy allows for osseointegration of the bone into the superior aspect of the fossa component and provides a method to attach the polyethylene to the metal base of the fossa component. The ramus component is constructed of titanium alloy, and the condylar head is composed of chromium cobalt alloy. This provides a metal-on-polyethylene articulation, which is the gold standard in orthopedics (Fig. 8.12). The screws are composed of titanium alloy and are 2 mm in

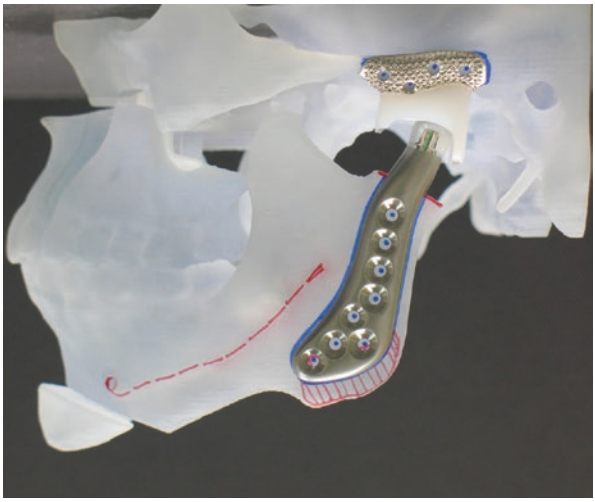

Fig. 8.12 The TMJ Concepts prosthesis is a custom-fitted device. The fossa component is composed of pure titanium shell fitted to the fossa with the shell covered in a titanium mesh. The mesh allows osteointegration of the bone in the fossa with the prosthesis. The mesh also provides a method to attach the polyethylene articular portion. The mandibular strut is made of titanium alloy, and the condylar head is chromium cobalt alloy. This prothesis is mounted on a 3D stereolithic model constructed with virtual surgical planning to place the maxilla and mandible into their new and final position along with a genioplasty

diameter. The fossa component is stabilized with four bone screws, and the mandibular component is usually designed to accommodate eight to nine bicortical bone screws. The fossa component is designed with a posterior stop that keeps the condyle of the mandibular component into a stable home base position.

There are numerous published research studies evaluating the outcomes using TMJ Concepts prostheses. Only a few of the studies will be presented herein. Mercuri et al. [30] published a multicenter study in 1995 presenting the outcomes of 215 patients (202 females, 13 males) with 363 total joint prostheses placed. The average age of the patients was 40.9 years with a mean follow-up of 48 months. The study revealed a 58% decrease in pain, a 51% increase in jaw function, a 55% increase in dietary consistency, and a 27% increase in maximum incisal opening. The greater the number of previous TMJ surgeries, the less favorable the outcomes.

Wolford et al. [31] published a 5-year follow-up study in 2003 that involved 38 patients (37 females) with 68 total joint prostheses placed at the average age of 36 years. Follow-up averaged 73.5 months. The number of previous TMJ surgeries was an average of 2.9. Three groups of patients were evaluated: group 1, 0–1 previous surgeries; group 2, two or more previous surgeries; and group 3, patients with previous Proplast Teflon or Silastic implants prior to placement of the total joint prostheses. In all three groups, the incisal opening improved, and the pain levels decreased, with the best pain outcome for group 1 and the worse with group 2 that had two more previous TMJ surgeries. Jaw function improved in all three groups.

Coleta et al. [32] performed a stability study with bilateral TMJ Concepts total joint prostheses used to reconstruct the TMJs and advance the mandible in 47 females that required counterclockwise rotation of the maxillomandibular complex. Pogonion advanced a mean of 18.4 mm and AP relapse was −0.1 mm. Occlusal plane was rotated counterclockwise with a decrease in angulation of −14.9°, and the relapse was 0.6°. Maxillary incisors advanced 5.6 mm with a relapse of −0.4 mm. The oropharyngeal airway increased an average of 4.9 mm. This study demonstrated the significant stability of the maxillomandibular complex undergoing counterclockwise rotations with the use of the TMJ Concepts total joint prostheses used to reconstruct the TMJs and advance the mandible (Figs. 8.13, 8.14, and 8.15).

Pinto et al. [33] evaluated the same 47 female patients receiving total joint prostheses and counterclockwise rotation of the maxillomandibular complex. There was a statistically significant improvement in facial pain, headaches, TMJ pain, jaw function, diet, disability, and incisal opening. There was a decrease in excursion movements. Fewer previous surgeries resulted in better outcomes in all parameters.

Wolford et al. [34] published a prospective cohort study evaluating 56 patients using Techmedica/TMJ Concepts patient-fitted TMJ TJR devices from 1989 to 1993. Median follow-up was 21 years. Mean age at surgery was 38.6 years. Median number of previous TMJ surgeries was 3. Presurgery and longest follow-up data comparison demonstrated statistically significant improvement for maximum incisal opening, TMJ pain, jaw function, and diet. At longest follow-up, 48 patients (86%) reported improved quality of life, 6 patients (11%) remained the same, and 2 patients (4%) were worse. Increased number of previous surgeries resulted in lower levels of improvement for TMJ pain and maximum incisal opening.

Numerous studies have been published by Wolford et al. [20, 21, 31–43], Mercuri et al. [30, 44–54], and others [55, 56] in reference to outcome data using TMJ

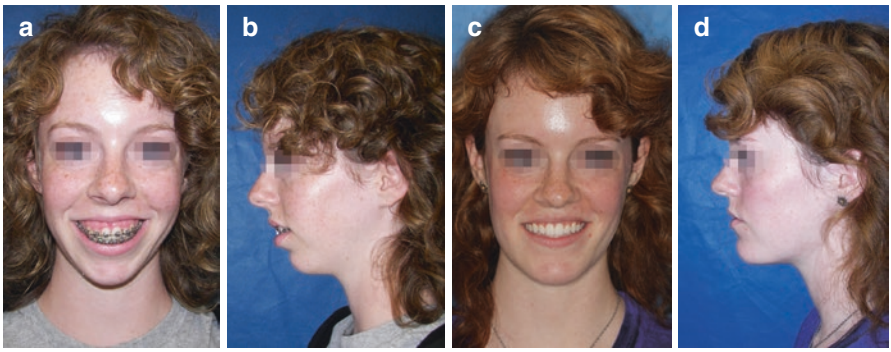

Fig. 8.13 (**a**) A 16-year-old female with bilateral TMJ adolescent internal condylar resorption (AICR) with non-salvageable discs and significant condylar resorption coupled with anterior maxillary vertical hyperplasia. (**b**) Shows the profile illustrating the retruded maxilla and mandible. (**c**) Is a 2-year follow-up that included bilateral TMJ reconstruction and mandibular advancement with the TMJ Concepts total joint prosthesis coupled with superior repositioning of the maxilla and a genioplasty. (**d**) Demonstrates the improvement in the profile

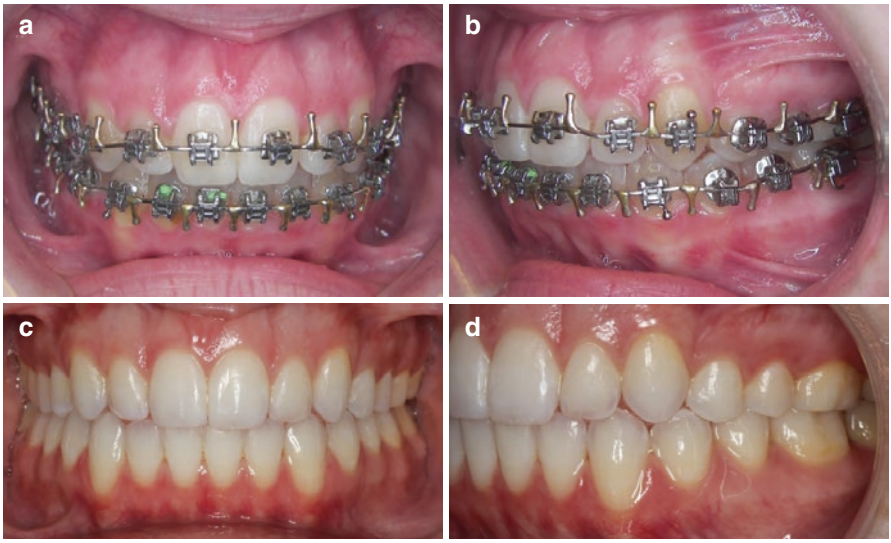

Fig. 8.14 (**a, b**) Demonstrates the presurgical occlusion. The patient has been in orthodontics for an extended time period enabling the orthodontist to keep the occlusion reasonably aligned. (**c, d**) shows the 2-year follow-up occlusal relationship

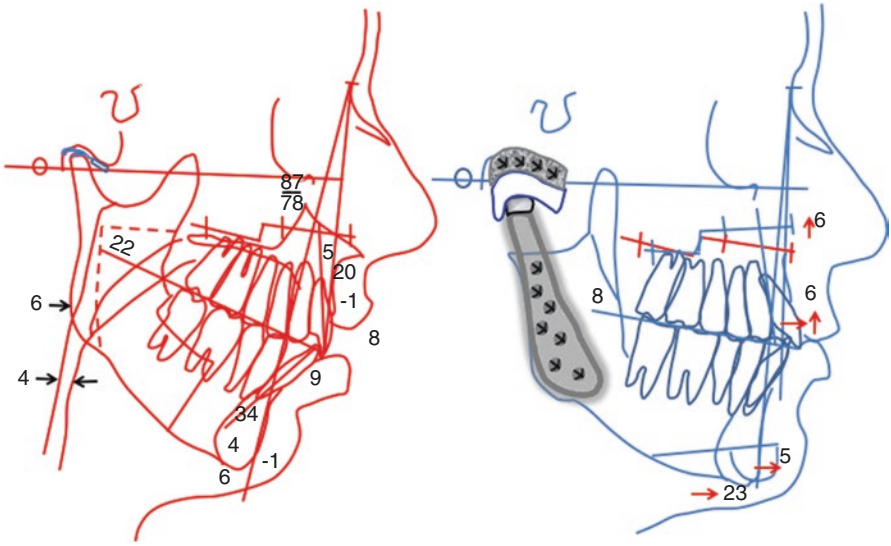

Fig. 8.15 (**a**) Lateral cephalometric analysis shows the maxillary vertical hyperplasia but AP hypoplasia of the maxilla and mandible and the high occlusal plane angle facial morphology. (**b**) The prediction tracing illustrates the counterclockwise rotation of the mandible using TMJ Concepts total joint prostheses as well as maxillary osteotomies to move the anterior maxilla upward in a counterclockwise direction. Genioplasty was performed to augment the chin and finalize the profile change

Concepts total joint prostheses. A summary of these publications have produced the following facts in reference to the TMJ Concepts total joint prostheses:

1. TMJ Concepts prostheses are superior to autogenous tissues for end-stage TMJ reconstruction relative to subjective and objective outcomes.
2. After two previous TMJ surgeries, autogenous tissues have a high failure rate, whereas patient-fitted total joint prostheses have a high success rate.
3. No donor site morbidity.
4. Increased number of previous TMJ surgeries produces a lower level of improvement related to pain and function outcomes compared to patients with 0–1 previous TMJ surgeries.
5. Failed TMJ alloplastic reconstruction (i.e., P/T, Silastic, metal-on-metal articulation, etc.) can create a foreign-body giant cell reaction and/or metallosis, best treated by joint debridement and reconstruction with patient-fitted total joint prostheses.
6. Fat grafts packed around the articulating area of the prostheses improve outcomes relative to decreased pain, improved jaw function, and decreased requirement for repeat surgery.
7. Osseointegration of the TMJ Concepts fossa and mandibular components occurs and is important for long-term stability.
8. Posterior stop on the fossa component is important to stabilize the joint, jaw position, and occlusion.
9. Concomitant orthognathic surgery can be performed at the same time as the TMJs are reconstructed.
10. 20-year follow-up study [34] demonstrated improvements in pain, jaw function, diet, incisal opening, and quality of life.

Advantages of the TMJ Concepts system:

1. Patient-fitted device for the patient's specific anatomical and functional requirements.
2. Metal-on-polyethylene articulation; the gold standard in orthopedics.
3. Surgeon has input for device design.
4. The fossa and mandibular components osseointegrate.
5. Posterior stop on the fossa essential for predictable control of the occlusion and facilitates concomitant orthognathic surgery.
6. A 3D stereolithic model is produced to aid in surgical preparation as well as the design and manufacturing of the devices.
7. Orthognathic surgery can be performed concomitant with the TMJ reconstruction. Enables the correction of minor to severe dentofacial deformities.
8. Large resections of the mandible for tumor removal can be reconstructed.

The disadvantages of this device are:

1. Requires presurgical planning and 3D stereolithic model preparation.

2. Manufacturing of the device takes 12 weeks.
3. May require two-stage surgery for removal and reconstruction of failed metallic TMJ prostheses (i.e., Christensen or nexus devices).
4. Alterations to fossa and ramus performed on the 3D model must be accurately duplicated on the patient.

8.16 Comparative Studies for Autogenous Versus Alloplastic Condylar Replacement

There are few published studies evaluating outcomes for condylar replacement comparing autogenous versus alloplastic reconstruction. Henry and Wolford [35] compared autogenous tissues versus Techmedica (currently manufactured by TMJ Concepts) total joint prostheses in patients who had failed Vitek Proplast/Teflon inter-positional implants or Vitek/Kent total joint prostheses. There were 107 patients in this study with a mean follow-up of 4 years. The following autogenous graft systems were used, and the percentage of success is in parentheses:

1. Costochondral grafts (12%)
2. Sternoclavicular grafts (21%)
3. Dermal grafts (8%)
4. Temporofascial grafts (13%)
5. Temporofascial grafts in conjunction with sagittal split osteotomies (31%)
6. Auricular cartilage (25%)
7. Techmedica total joint prostheses (86%)

These multiply operated patients who had previously failed alloplastic implants demonstrated extremely poor outcomes with the use of autogenous tissues where the success rate ranged from 12 to 31%. The Techmedica total joint prostheses had a relatively high success rate (86%).

Frietas et al. [57] evaluated 12 patients with 24 operated joints. Six patients received costochondral grafts or sternoclavicular grafts, and six patients received TMJ Concepts total joint prostheses. The follow-up ranged from 48 to 58 months. The total joint prostheses provided statistically significant better objective and subjective outcomes, decreased the operating room time, and produced significantly better skeletal and occlusal stability particularly when the maxilla and mandible were advanced.

Wolford et al. [58] evaluated 13 patients with TMJ ankylosis from the age of 5 to 15 years. Four patients received costochondral grafts, six sternoclavicular grafts, and three total joint prostheses with a follow-up of 2–13 years. Seven of the 13 patients had fat grafts packed around the reconstructed TMJs. Of the four costochondral grafts, three grafts demonstrated excessive growth. None of these grafts had fat placed around and all four re-ankylosed. Four patients received sternoclavicular grafts and had fat grafts packed around the articulating area of the grafts. There was no re-ankylosis in this group, and they had good jaw function, although decreased translation ability. Two of the sternoclavicular grafts did not receive fat grafts and both re-ankylosed. With the sternoclavicular grafts, any that had

significant mandibular advancement also experienced some relapse as the grafts remodel some under increased loading to the joints that occurs with mandibular advancement. The three patients that received the total joint prostheses had fat packed around the prostheses. There was no re-ankylosis nor mandibular relapse. The incisal opening presurgery ranged from 2 to 29 mm, and post surgery ranged from 35 to 52 mm, demonstrating good outcomes with the total joint prostheses. The use of fat grafts packed around the articulation area of the autogenous sternoclavicular grafts and around the total joint prostheses prevented re-ankylosis of the TMJs.

Saeed et al. [59] evaluated 49 patients receiving 66 costochondral grafts and 50 patients with 68 total joint prostheses using the Christensen system with metal-on-metal articulation. Mean follow-up ranged from 43 to 49 months, and mean age was 38 years. The authors reported complications in 27 patients receiving costochondral grafts and 34 patients that received the total joint prostheses. However, the authors reported 26 of 49 patients (53%) required reoperation in the costochondral graft group, whereas only 6 of 50 patients (12%) receiving the total joint prostheses required reoperation by the end of the study period. The total joint prostheses provided better subjective and objective outcomes. The authors' recommendations from this study were that total joint prostheses are recommended in cases of ankylosis, multiply operated joints, and previously failed alloplastic implants.

These comparative studies demonstrate the following:

1. Total joint prostheses provide better outcomes relative to pain, function, stability, and esthetics compared to autogenous grafts.
2. Total joint prostheses eliminate the requirement for bone graft harvest, but it is recommended that fat be harvested and packed around the functioning area of the prostheses.
3. With the use of total joint prostheses, concomitant TMJ and orthognathic surgery can be performed at the same operation with highly predictable outcomes relative to stability, function, esthetics, and decrease in pain.
4. Total joint prostheses work better in poorly vascularized tissues and multiply operated TMJs as do vascularized grafts, compared to free autogenous grafts.
5. Patient-fitted total joint prostheses do require presurgical preparation that is more extensive than autogenous tissues or off-the-shelf total joint prostheses, but the surgery is significantly easier and surgery time shortened because of less surgical requirements compared to fitting the off-the-shelf devices.
6. For ankylosis cases, packing fat grafts around the articular area of the autogenous grafts or alloplastic total joint prostheses decreases the risk of heterotopic bone formation and re-ankylosis.

8.17 Prosthesis Longevity

The longevity of a prosthesis for any joint is dependent on materials, design, stability, and functional loading. When the Techmedica patient-fitted CAD/CAM TMJ prosthesis was first introduced, the only guide for joint replacement device

longevity was based on the orthopedic literature since this prosthesis was composed of the same materials considered as the gold standard in orthopedics [60, 61]. However, orthopedic stability studies could not be applied since hip prostheses were stabilized and fixated by different methods including wedging and bone cements. A big issue contributing to hip prosthesis failure involves functional loading that is based on design, materials, articulation, size of articulating components, and body weight. This results in a functional load that can range from 3.5 to 6 times the body weight [62]. Theoretically, the functional load delivered to the hip articulation in a 180-pound individual would be between 630 and 1080 pounds. For running and jumping the load maybe ten times the body weight or 1800 pounds. It is difficult to determine the functional load for the TMJ prosthesis. For the average individual, the biting forces generated at the molars are approximately 60 pounds and for the incisors 35 pounds [63]. Many of the patients requiring TMJ TJR may have significantly lower biting forces creating even lower functional loads. This may explain the longevity of the TMJ Concepts patient-fitted CAD/CAM TMJ prostheses since none of the patients in The Wolford et al. 20-year study [34] required replacement because of wear issues.

8.18 Fat Grafts

Wolford and Karras [64] introduced the use of fat grafts around the articulating area of the total joint prostheses. Earlier experiences demonstrated significant scar tissue formation as well as reactive bone around the articulating areas of the prostheses often creating pain as well as limited jaw function and requiring reoperation for debridement. The theory for using fat grafts is as follows: (1) eliminates dead space, (2) prevents blood clot formation around the total joint prostheses articulating area, (3) inhibits bone growth and fibrosis, (4) decreases pain, and (5) improves joint function.

The Wolford and Karras study [64] evaluated two groups of patients. Group 1 consisted of 15 patients (13 females and 2 males) and 22 joints (7 bilateral, 8 unilateral) that received fat grafts around the prostheses. Group 2 included 20 patients (18 females and 2 males) and 33 joints with 17 bilateral and 3 unilateral. For group 1, no additional surgery was required post surgery when the fat grafts were placed concomitantly with the total joint prostheses. In group 2 that did not receive fat grafts at the initial surgery, 35% of the patients required reoperation for heterotopic bone and/or fibrosis.

Wolford and Morales [20] reported on 115 patients receiving total joint prostheses, with all patients receiving placement of autogenous fat grafts around the articulating area of the prostheses. Christensen and TMJ Concepts prostheses were involved in this study with 88 patients receiving bilateral total joint prostheses and 27 received unilateral total joint prostheses for a total of 203 TMJs reconstructed. There were two groups divided as follows: group 1 received Christensen devices ($n = 42$ patients, 76 joints), and group 2 consisted of TMJ Concepts total joint prostheses ($n = 73$ patients, 127 joints). Of the patients who received Christensen prostheses, 25 of the 76 (33%) required removal because of severe pain due to device failure (fossa fracture) or severe

metallosis and metal hypersensitivity. Despite the problems leading to prosthesis removal, none of the patients demonstrated significant fibrosis or heterotopic bone formation around the prostheses. Four of the 127 (3%) TMJ Concepts prostheses were removed from 2 patients because of severe pain due to severe metal hypersensitivity. One patient maintained the fat grafts around her prostheses, and the second patient developed fibrotic tissues around the prostheses, but no heterotopic bone was noted. Ten patients (8.7%) developed morbidity at the fat graft donor site post surgery. Two obese patients developed abdominal cysts superficial to the rectus abdominis muscles that required surgical removal, and eight patients developed seroma formation requiring aspiration. The results of this study support the efficacy of autologous fat grafts in TMJ total joint prosthetic reconstruction. A statistically significant improvement for both groups was found regarding MIO and patient's perception of jaw function. The removal of 29 prostheses over a follow-up period of 12–65 months was due to problems other than fat graft-related complications.

The most common donor site for fat harvesting is the abdomen, where there is usually abundant or at least adequate fat for most cases. The most common approaches the author uses include the suprapubic incision, the umbilical or transnaval incision, or approach through a preexisting scar (e.g., C-section, hysterectomy, appendectomy, abdominoplasty). However, the fat can be harvested from almost any fat source including buttock, thigh, buccal fat pad, breast, etc. Following fat harvest, good hemostasis of the donor site is required and a pressure dressing applied along with an abdominal binder (for abdominal donor site) for 3–4 days post surgery to prevent hematoma or seroma formation. If adequate hemostasis cannot be achieved, then a drain with negative pressure may be indicated for a few days.

Autogenous tissue grafts have been advocated by some surgeons for TMJ reconstruction [1]. However, some of these aforementioned TMJ conditions can have an adverse effect on the viability of autogenous tissue grafts as well as the physiological impact on the grafts, resulting in a significant incidence of graft failure. The potential risks and complications provide additional concerns when considering and utilizing autogenous tissues. Therefore, TMJ reconstruction with total joint prostheses should be a primary consideration when TMJ condylar replacement is required. TMJ alloplastic replacement usually provides a more predictable outcome for patients with any of the end-stage TMJ conditions.

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