Journal of Dentistry and Oral Biology

Review Article
Published: 17 Feb, 2024

Temporomandibular Joint Disorders – To Be or Not to Be

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Abstract

Temporomandibular joint is the articulation between the condyle of the mandible and squamous portion of the temporal bone. Temporomandibular joint develops between 8 to 14 weeks compared to 5 to 4 weeks for the synovial joints. Despite the considerable technical advances in this field over last decades, the reconstruction of the Temporomandibular joint is still controversial, and it continues to represent an important challenge to oral and maxillofacial surgery. Among the therapeutic proposal which have been put forward for tissue defects of anatomical structures of this joint, there is reconstructive abstinence, autogenous tissue reconstruction and joint prostheses. Reconstruction of temporomandibular joint proves to be challenging for the surgeon with limitations due to donor site morbidity, or reconstruction with the engineering design and materials of total joint replacement. TMJ reconstruction should be considered in management of the following conditions such as inflammatory arthritis involving TMJ not responsive to other modalities of treatment, recurrent fibrosis or bony ankylosis, failed tissue graft, failed alloplastic joint reconstruction, loss of vertical mandibular height or occlusal relationship because of bony resorption, trauma, developmental abnormalities or pathologic lesions. In this review article, reconstruction, rehabilitation and restoration of temporomandibular joint has been highlighted.

Keywords: Joint; Dental; Oral; TMJ; Prosthesis; Pathology

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Received Date: *31 Jan 2024*
Accepted Date: *13 Feb 2024*
Published Date: *17 Feb 2024*

Citation:
Balamurugan L, Jaganbabu, Shivangi V, Krishnamoorthy A, Rajasekhar B, Karthik S, et al. Temporomandibular Joint Disorders – To Be or Not to Be. J Dent Oral Biol. 2024; 9(1): 1225.
ISSN: 2475-5680

Introduction

TMJ reconstruction can be carried out by utilizing alloplastic, allogenic, or autogenous materials [1-5]. The main aim of reconstruction of TMJ is to regain facial form [6], improve mandibular function and form, reduce suffering and disability [6] and [7] prevent morbidity. Disease with functional and anatomic distortion determines the need for total joint reconstruction.

Because joint function and its related muscle function are so complex, a reconstructed joint cannot reasonably be expected to return to normal premorbid function. Therefore, any reconstructed joint will always have some functional disability [7]. In Temporomandibular joint, reconstruction is of various types of autogenous graft has been used costochondral graft sternoclavicular, fibular, tibial, iliac crest. However traditionally most used by maxillofacial surgeon has been the costochondral graft [8]. The first indication of autogenous interposition in the TMJ was ankylosis. It may be that Verneuil was the first to use such tissues, employing the temporalis flap in 1860. Ridson applied free muscles to the problem in 1934 and more recently Feinberg and Larsen and Albert and Mercill described rotation of temporalis muscle flaps for replacement of the TMJ disc. In 1914 Murphy reported the use of autogenous fat for interposition after lysis of TMJ ankylosis [8]. The use of autogenous auricular cartilage as a sternoclavicular graft offers significant advantages as it is embryologically and histologically similar to the mandibular condyle area.

Wolford et al. defend the sternoclavicular graft obtained from the cranial half of the contralateral clavicle. Some authors favor the use of the sternoclavicular graft for the reconstruction of mandible growing patients defending that growth capacity is compatible with ascending branch of the mandible. However, others consider that there are no significant differences in the potential for

mandibular growth between reconstruction with sternoclavicular and with costochondral grafts. On the other side, other author considers that surgical complexity of the sternoclavicular graft and potential morbidity of the donor site has been discouraging with regard to their application in general as substitutes for the mandibular condyle.

Metatarsal bone graft has a long history as condyle substitutes, since Bardenheuer first explained it in the year 1906. They permit an excellent anatomical adaption to the temporal fossa, but the absence of cartilage favors the development of ankylosis. Even though it prevents from a potential for epiphysarian growth, its capacity to adapt to the growth and function of the mandible have not been considered adequate. Studies by Dingman and Grabb in the mid-sixties showed that there was a progressive reabsorption of non- vascularized metatarsal grafts used in the reconstruction of the condyle, with resulting retrognathia and lateral deviation of mandible.

Later in 1986, Datillo et al. published the successful reconstruction of TMJ with the second, free, vascularized metatarsophalangeal joint, pedicled to dorsalis artery and comitant veins. The principal disadvantages that are attributed to autogenous grafts in reconstruction of TMJ are derived from the addition of inevitable donor site morbidity, and of the variableness of biological behavior with regard to reabsorption capacity, development of ankylosis and growth of the graft. However, the greatest disadvantage is probably that the start of postoperative rehabilitation of the joint is delayed. At the present time the transfer of vascularized, autogenous based on microsurgery techniques is a form of treatment widely accepted in our anatomic area. Even though microsurgical reconstruction of the TMJ have been described with iliac crest the free flap most frequently used in these reconstructions is the fibula. Excellent results have been found in the literature with microvascularized fibular flaps in children.

Even though unpredictable tendency for reabsorption and degenerative changes in the long term, disadvantages classically attributed to free non-microvascularized grafts, there are also references in the literature to morphological alterations in longer follow up studies of vascularized grafts. The principal advantages of microsurgical temporomandibular joint reconstruction are the best in tri dimensional stability in the long term, reconstructive versatility and the minimum capacity for developing complications [9]. Total TMJ replacements suggest that a history of multiple previous failed operations is the most common indication for joint replacement and patients with severe osteoarthritis, inflammatory arthrosis, connective or autoimmune disease ankylosis, absent or deformed structure, congenital deformities, and chronic pain [9].

The entire TMJ replacement is a ball and socket type prosthetic joint [10]. The entire TMJ replacement procedure comprises 3 components i) condylar or mandibular implant, ii) the fossa implant, and iii) screws. Surgical intervention of temporomandibular joint has two modalities' restorations of joint's normal anatomy and the decompression of joints structures. Both requirement to should lead to a clinical situation of lack of pain and recovery of the joint function. These are the final objectives have to be present when considering the option of the temporomandibular joint.

According to some authors total replacement of the TMJ structures with certain alloplastic prostheses can give better results in patients that have been subjected to multiple interventions and that have a vascular necrosis of the condylar segment. However other authors suggest a more spread-out practice of using autogenous tissue as a definitive re-construction technique. With patients that have experienced treatment with alloplastic prostheses, and removal has been necessary it has been demonstrated that the osteoclastic reaction persists even after the removal of the implant probably as a result of dissemination particles into the adjacent, pathological tissue. Because of this, eliminating all the adjacent pathological tissues is advised before planning renewed reconstruction.

This philosophy of delaying autogenous reconstruction allows for the maturing of scar tissues, obtaining revascularization, re-establishing muscle tone, and resolving or minimizing previous inflammatory responses. Premature re-intervention would increase potential morbidity, scarring and risk of development of ankylosis. Some authors consider that the TMJ prosthesis are better for reproducing the normal anatomy of the joint, restoring vertical dimensions with greater fidelity. The latest development of made to measure, separate prostheses for each patient has, in this respect, had a great influence in all events, autogenous tissue has conventionally showed an adequate surgical malleability regarding defect adaptation. This adaptability of autogenous grafts even appears to persists spontaneously and once placed in the recipient bed, they adapt and remold themselves adequately to the function to which they are subjected. Other merits, which are generally attributed to the TMJ prostheses, include prevention of donor site morbidity, reduction in operative time, immediate start of physical rehabilitation and minimizing the recurrence possibility of joint ankylosis.

The potential disadvantage of alloplastic prosthesis is fundamentally determined by their poor wear characteristics and material breakdown. Some authors stress the lack of flexibility of these prostheses for adapting to the morphology of the ascending mandibular branch especially the length and their limited adaptability to the glenoid fossa as an additional element in the development of all these complications. Apart from this is its morphological long-term stability, which is not recommended in growing children. Other disadvantages described of heterogenous material are its capacity for causing the formation of dystrophy bone, the development of severe infections complications and the substantial increase in costs associated with this reconstruction.

The use [11] of alloplasts in reconstruction of the temporomandibular joint has provoked the greatest calamity in the history of oral and maxillofacial surgery.

The attempts of Gluck with ivory prostheses a century or more ago, and use of Vitallium by Castigliano and Gross and then Klrtich 50 years ago are notable in this regard. The use of transport distraction osteogenesis in temporomandibular joint reconstruction is very effective technique that offers an alternative to autogenous bone grafting and prosthetic joint replacement in the reconstruction of the ramus-condyle unit. Transport distraction osteogenesis can be used in case of certain tumor or of extensive. The great advantage of the use of transport DO in the management of ankylosis is that extensive bone removal is possible, creating a large gap that discourages recurrent heterotopic bone formation [11].

Clinical Signs of TMJ Disease

TMJ [12] fractures and Luxation's are the result of local trauma, kicks, or accidents in which the horse's head is caught and jammed through an opening and, as the horse panics to extricate itself, the head mandible and TMJ may be injured. Such conditions present

as acute cases and show pain on palpation and manipulation, local swelling, and asymmetry of the face and incisor alignment. TMJ arthritis and chronic "wear and tear" lesions from dental arcade irregularities myopathic and fibrous scaring are difficult to isolate from the etiopathologic condition, and step mouths are diagnosed by oral examination and radiography [12].

Investigation

1) OPG

2) AP or PA view skull

3) CT

4) MRI

5) Lateral Tomography

Protocols for patients requiring total temporomandibular joint reconstruction

Children [13] with congenital deformities, but no an ankylosis (usually otomandibular dysostotic or syndromic patients)

1) If no ankylosis has ensued, and there is no evidence of residual alloplastic or reactive tissue, visually, tactilely, or on frozen section, reconstruction with autogenous soft tissues for disc replacement and a costochondral graft.

a. If there is evidence of residual alloplastic or reactive tissue, repeat their extirpation, avoid immediate reconstruction, monitor for a minimum of another 12 months and repeat surgical exploration thereafter

2) If ankylosis has ensued, but there is no evidence of residual alloplastic or reactive tissue, reconstruct immediately with dermal or autogenous soft tissues as a disc replacement and a costochondral graft.

a. If residual alloplastic or reactive tissue is present, repeat its extirpation, defer reconstruction, observe for another minimum of 12 months, and repeat surgical exploration thereafter

IV. Adult patients reportedly having had all previous alloplasts removed.

A. Observe for a minimum of 12 months after most recent surgery

B. Reinvestigate surgically thereafter

1. If there is no evidence of residual alloplastic or reactive tissue, reconstruct immediately with dermal or other autogenous soft tissue disc replacement and a costochondral graft.

2. If residual alloplastic or reactive tissues is present, aggressively remove all such elements, observe for another 12 months and repeat surgical exploration thereafter

V. Adult patients with ankylosis independent of previous alloplastic surgery (usually as a result of trauma or non-alloplastic temporomandibular joint interventions).

A. Observe for a minimum of 12 months after the injury or most recent surgery.

B. Reintervene surgically thereafter

1. In case of first-time ankylosis, remove ankylotic tissue and reconstruct immediately with dermal or other autogenous soft tissues disc replacement and a costochondral graft.

2. In case of re-ankylosis after earlier attempts at lysis of initial ankylosis, remove ankylotic tissue place inter-positional dermal or other autogenous soft tissue grafts and defer condylar reconstruction.

a. monitor for 12 months additionally

b. Re-intervene surgically after that

- If no re-ankylosis, reconstruct immediately with costochondral graft;
- If re-ankylosis has occurred, lyse the ankylosis and observe for another 12 months, repeat surgical exploration thereafter [13].

Approaches for TMJ reconstruction

- In Birmingham [14], a pre-auricular approach was combined with an incision over the ramus of the mandible just above the angle. In Gloucester, a retrotragal pre-auricular incision and altered retromandibular incision was used. Generally, the outer layer of the temporal fascia was split above the zygomatic arch as described by Bramley and Al Kayat to reduce the risk to the frontal branch of the facial nerve. In respect of full bony ankylosis, the temporalis muscles were incised down to bone and raised with skin flap, as explained by Norman. Where ever previous scars, they were re-opened in preference to the above incisions, and unsatisfactory scars were excised.

Autogenous reconstruction of temporomandibular joint

Despite the considerable technical advances is our field over the last decades, the reconstruction of the Temporomandibular Joint (TMJ) is still controversial, and it continues to represent important challenge to oral and maxillofacial surgeons [14]. Among the therapeutic proposals which have been suggested for tissue defects of anatomical structures of this joint, there has been reconstructive abstinence, autogenous tissue reconstruction and joint prostheses

In the beginning of the 21st century, it would not be easy to justify the non-reconstruction of a TMJ. There will be lot of aesthetic concerns for the patient; mandibular movement would be significantly compromised, with a clear ipsilateral-lateral deviation of the mandible, and a loss of common functions like mastication or even swallowing.

Full reconstruction of TMJ by use of grafts of flaps from the patient himself is till today the technique of choice in most cases. The main advantage is the biological compatibility of autogenous tissue, which is conventionally associated with reconstructive techniques. Other advantages include the ease with which they can be surgically manipulated, functional adaptability, minimal capacity for infection and for the development of immunology mechanisms, and the reduction in medical costs. The latter are characteristics that give reconstructions by autogenous tissue a significant role in the maintenance of the biological and functional wellness of the patient. The likelihood of the patient facing additional injury in the event of therapeutic failure is unlikely and of negligible consequence, as against what happens with alloplastic prostheses.

The indication for reconstruction of the Temporomandibular Joint (TMJ)

The indication for TMJ reconstruction includes ankylosis [15], severe osteoarthritis, rheumatoid arthropathy, neoplastic disease, posttraumatic dysfunction and congenital disease. The objectives

of reconstruction are restoration of mandibular function and form, reduced patient disability and suffering and the arrest of disease progression. The method of reconstruction, however, is controversial and numerous techniques both autogenous (fibula, metatarsal, sternoclavicular, iliac, and costochondral) and alloplastic (acrylic, synthetic fibers, ulnar head prosthesis, compressible silicon rubber and complete joint systems) have been described.

The most prevalent and accepted autogenous technique is a costochondral graft, and as stated by MacIntosh the advantages of this graft are its biological compatibility, workability, functional adaptability, and minimal additional detriment to the patient. The growth potential of the costochondral graft makes it the ideal choice in children. Potential problems are fracture, further ankylosis, donor site morbidity and the variable growth behavior of the graft [15].

Autogenous grafts for the reconstruction

In the medical literature, there are many publications, which advocate the advantages of reconstructing bone defects by means of autogenous grafts. In TMJ reconstruction, various types of autogenous grafts have been used costochondral, sternoclavicular, fibular, tibial, iliac crest, cranial calotte or metatarsal. However traditionally, the frequently used by maxillofacial surgeons is the costochondral graft.

The costochondral graft is autogenous tissue, which is over a period of time the most accepted in TMJ reconstruction. Initially described by Gillies in 1920. The use of the cartilaginous component associated with the costal bone in the temporomandibular arthroplasty was made popular by Longacre and Gilby in the 50s decade. The advantages enumerated by Mclntosh are biologically compatibility, easy work technique, accessibility, functional adaptability, versatility and minimum additional morbidity for the patient. The growth possibility of the costochondral graft due to the incorporation of growth centers in the transplant makes its application in child TMJ reconstruction ideal. With regard to other autogenous grafts, the advantages of costochondral grafts reside in a low complications and morbidity incidence in thoracic area, its adaptability to the mandibular bed and especially the incorporation of a cartilaginous tissue pad which favors morphological and functional adaptation and reduces the relapse of ankylosis.

However, some authors choose other reconstruction alternatives due to the inferior quality of the cortical and medical bone of the costochondral graft, the flexibility and elasticity of the bone, the facility for deformation on being subjected to continuous stress which gives rise to occlusal alterations, the possible fracture of bone cartilage of the graft and unpredictable growth.

Among potential complications described, of note is the risk of fracture of the graft, infection with partial or total re-absorption of itself, morbidity of the donor site, the variable capacity of growth of the graft and especially the possibility of renewed ankylosis. Ankylosis after a costochondral graft is not very frequent and in most of the cases, it occurs after a reconstruction carried out because of previous ankylosis. The inter-position tissues described in the literature to minimize re-ankylosis are multiple, including temporal muscles, cartilages, fascia, fat, dermis, or skin (all of it NT).

In the literature, there are some controversies on the method of adaptation of the graft and its fixation. Even though some authors prefer the use of mini-plates for the fixation of grafts including making a green stick fracture so as to increase adaptation to the ascending mandibular branch and glenoid fossa, fixation with bicortical screws is equally suitable.

Some authors consider that the sternoclavicular graft offers significant advantages as it is embryologically and histologically similar to the mandibular condyle and with regards to potential growth, it is adaptable to the mandibular condyle area. Wolfard et al. defend the sternoclavicular graft obtained from the cranial half of the contralateral clavicle. Using the criteria that therapeutic success consists in the reduction or elimination of pain, obtaining stable occlusion and adequate mobility of jaw, with an inter-incisor opening superior to 30 mm, these authors find better results in cases not previously reconstructed with prosthetic systems in which there is neither inflammatory pathology of the joint. In these cases, therapeutic success is rated as 93% of patients. Complete reconstruction of the TMJ with a portion of the sternal manubrium to substitute the portion of temporal bone of the joint has even been described [16].

Some authors favor the use of the sternoclavicular graft for the reconstruction of the mandible for growing patients, defending that growth capacity is compatible with the ascending branch of the mandible. However, others consider that there are no significant differences in the potential for mandibular growth between reconstructions with sternoclavicular and with costochondral grafts.

On the other hand, other authors consider that surgical complexity of the sternoclavicular graft, and potential morbidity of the donor site, have been discouraging with regard to their application in general as substitutes for the mandibular condyle. In the clavicular donor site, 10% clavicular fractures have been reported, 50% of which required open reduction.

Metatarsal bone grafts have been long known in the history as condyle substitutes since Bardenheuer first mentioned them in 1906. Metatarsal bone grafts permit an excellent anatomical adaptation to the temporal fossa. But the absence of cartilage favors the development of ankylosis. Though they conserve a potential for epiphysarian growth, their ability for adapting to growth and function of the mandible has not been found adequate. Studies by Dingman and Grabb in the mid-sixties indicated that there was a progressive re-absorption of non-vascularized metatarsian grafts used in the reconstruction of the condyle in five patients resulting in retrognathia and lateral deviation of the mandible. This led to the technique being abandoned. Later in 1986, Datillo et al. published the successful reconstruction of the TMJ with the second, free, vascularized metatarsophalangeal joint, pedicled to dorsalis pedis artery and comitant veins. Other lateral works, despite only being in a reduced number of cases, confirmed the suitability of this reconstruction technique in condyle defects, with excellent aesthetic and functional results, including long term follow-up case and growing patients.

The invasion by osteogenic distraction mechanisms has been a significant advance in the reconstructive options for the head and neck. Even though the possibilities go beyond the scope of this article, considering bone reconstruction at the present time is impossible, without giving some thoughts to the uses, which the distractors on the market give us. Numerous references can be found in the medical literature on bone transport and distraction of the ascending mandibular branches to replace a condyle and even on distraction of autogenous grafts used earlier for refinement of aesthetic and functional results.

The main disadvantages that are ascribed to autogenous graft in

reconstruction of the TMJ are derived from the addition of inevitable donor site morbidity and of the variableness of biological behavior with respect to re-absorption capacity, development of ankylosis and growth of the graft. However, the greatest disadvantage is probably that the start of postoperative rehabilitation of the joint is delayed.

Costochondral graft can be expected to grow spontaneously in pediatric patients (i.e., those less than 15 years of age). Ankylosis of costochondral graft is rare in the children age group but can be problematic in adult patients, especially those who have undergone multiple operations with extensive fibrosis at the recipient site. For these patients, the risk of heterotopic bone formation is high.

In most cases, the contralateral rib is harvested for joint reconstruction. The ribs most commonly used for reconstruction of the joint reconstruction are the fifth, sixth and seventh ribs. The rib is harvested through a horizontal incision in the inflammatory fold. If two ribs are needed, they should be harvested on the same side (e.g.; the fourth and the sixth rib or fifth and seventh ribs) to prevent bilateral pneumothorax. Ribs from the ipsilateral side require more contouring because they do not have the ideal angulation.

After dissecting through the skin and subcutaneous tissue, the surgeon excises the periosteum with care on the under-surface of the rib to prevent pneumothorax. Leaving a strip of periosteum and perichondrium overlying the junction of the rib and the costal cartilages helps prevent the separation of the cartilage from the rib during function.

Approximately 1 cm of cartilage and 3 cm to 4 cm of bone is normally sufficient. After the rib is removed, the wound can be filled with saline and the Anesthesiologist can inflate the lungs to the maximum degree to look for the bubbling in the saline, an initial indication of pleural tear. Small pleural tears can be closed during that time.

An upright chest film should be obtained immediately after the surgery to ensure that pneumothorax has not occurred. Once the rib is harvested, a scalpel blade is used to contour the hyaline cartilage so that it stimulates the shape of the condylar head and fits in the fossa as well as possible. Decorticating the graft or the middle surface of the ramus is not required. The graft can be attached either to the lateral ramus or the posterior ramus with circumferential wires, bone screws, or a combination of plates and screws. The surgeon should be careful not to tighten the screws excessively because this can induce a longitudinal fracture in the rib. A small fixation plate is at times used along with the screws to act as a washer, dispersing the pressure from the screwhead. The superior lateral edge of the condylectomy margin need to be contoured to ensure that the rib is not displaced laterally by ramal bone. A combination of endaural incision and a posterior mandibular incision is necessary to properly position and secure the rib graft.

Intermaxillary fixation is necessary to allow for initial consolidation of the graft and usually appropriate for a period of 4 to 6 weeks. In addition, most clinicians use an acrylic splint that opens the vertical dimension 2 mm to1 mm to prevent early loading of the costochondral graft. Conversely, as prolonged intermaxillary fixation may lead to early ankylosis of the graft, several authors suggest that dermal or temporo-myofascial grafts be used in concert with the costochondral graft.

The role of microsurgery in TMJ reconstruction

Studies based on clinical evidence and experience suggest that associated morbidity is relatively low and risks, from the patient's point of view are acceptable. The main advantages of microsurgical temporomandibular reconstruction are the best tridimensional stability in the long term, reconstructive versatility and the low capacity for developing complications. The reconstruction of the TMJ with vascularized metatarsal has been mentioned previously. In 2003, Landa et al. published excellent results in a long-term following of 5 patients reconstructed with the second micro-vascularized metatarsophalangeal joint.

Even though microsurgical reconstructions of TMJ had been explained with the iliac crest, the free flap most often used in these reconstructions is the fibula. In clinical practice, majority of cases do not concern specific TMJ reconstructions, rather a wide range of mandibular defects, which involve this joint. The principle behind functional reconstruction with the insertion of soft tissue and the fixation of muscular structures to the neocondyle, gives better functional results to be achieved in the long run. Mitek type anchor systems have proved their usefulness in this type of reconstruction.

Similarly, excellent results have been found in the literature with micro vascularized fibular flaps in children. Even though there is an unpredictable tendency for re-absorption and degenerative changes in long run, disadvantages classically ascribed to free non-micro vascularized grafts; there are also references in the studies to morphological alterations in prolonged follow up studies of vascularized bone grafts. Guyot et al. discovered that the fibular neocondyle in radiological long term follow ups re-modelled itself in terms of rounding and thinning of the stump.

Alloplastic reconstruction of the temporomandibular joint

History: Alfred Stille [1] averred that "medicine, like all knowledge, has a past, present and a future, and.., in that past is soil out of which improvement must grow." Accordingly, a retrospection is important in a department of surgery, division of oral and maxillofacial surgery and dental medicine, Stritch school of medicine, understanding the use of alloplastic materials in joint reconstruction.

The citations made in this section are intended to show that many surgeons in the past found a need for alloplastic TMJ reconstruction in particularly difficult clinical situations. Furthermore, it provides records of descriptions of the material and methods used in these cases. Typically, the use of a material in reconstructive devices mirrors its introduction into industry and medicine. When these papers were evaluated, it was noted that in many cases the reports were of single case and the follow-up was generally 1 year. The only criterion for success being that the patient could open his mouth.

Therefore, no indications for use of the devices and no criteria for success were generally accepted until the studies reporting larger numbers of cases were presented. Before 1980 alloplastic joint replacement or resurfacing (hemiarthroplasty/partial joint replacement) was carried out mostly after ablative surgery and in cases of ankylosis, trauma, or serve joint disease. After the mid to late 1980s, partial and total TMJ devices were also being used to manage failed non-surgical and surgical TMJ patients.

The first recorded account of joint surgery was by a famous French barber-surgeon of the Renaissance, Ambrose pares, who in 1536 carried out the first joint excision on a patient with a destructive infection of the elbow. Between 1536 and 1840, surgical removal/ excision was the only treatment reported for acute joint disease. In 1840 John Murray Carnochan [8] a New York Surgeon was credited

with the idea of interposing material between the surfaces of a diseased joint. He reported an attempt to mobilize a patient's ankylosed TMJ by placing a small block of wood between the raw bony surfaces of the residual mandible after creating a gap at the neck of the condyle.

In 1890, a German surgeon named Gluck [9] reported total joint arthroplasties with ivory prosthetic TMJs and hip joints that he stabilized with a cement made of colophony, pumice and gypsum. In 1933 Ridson [1] reported treating a case of ankylosis of the TMJ by interposing of gold foil between the 631632 bony surfaces after a gap had been created. Eggers 11 (in 1946) and Goodsell 112 (in 1947) reported the use of tantalum foil in cases of TMJ ankylosis. In 1951, Castigliano 13 and Kleitsch 14 resurfaced the bone in TMJ ankylosis with Vitallium (Howmedica). In 1952 Smith [15] reported the use of stainless steel in hemiarthroplasty for ankylosis. Ueno et al. [17] reported experimental and clinical results with zirconium in TMJ ankylosis in 1955. In 1960 Henry [18] described replacement of an ankylosed TMJ with a prosthesis; that same year Robinson [19] reported correction of a TMJ ankylosis by means of an artificial stainless-steel fossa. Christensen, in 1963 [20], 1964 [21] and 1970 [22] reported resurfacing of the glenoid fossa with a thin Vitallium fossa-eminence prosthesis in cases of TMJ ankylosis.

He added a ramus-condyle component with a Polymethylmethacrylate (PMMA) head to a Vitallium ramal component to create a total joint prosthesis. In 1995 Chase et al. [23] reported on results with both of the devices that were then in use. A chromium-cobalt condylar head was offered in 1996 as an option to the PMMA. Recently Garrett et al. [3] reported the use of custom-designed modification of the standard Christensen total alloplastic. They reported 23 successful cases over 1 to 3 years of follow-up; success was defined by these authors as the patient's being able to open the mouth to eat without pain. In 1978 Kummoona essentially reproduced the work of Kiehn et al. in six monkeys. After 9 to 10 months of function, 50% of the reconstructions were unsuccessful due to condylar component failure. Microscopically there was a minimum of inflammatory cells, with no evidence of infection, and well-organized granulation tissue and collagen fibers were present, with fibrous tissue beneath the cement and condylar component. Reaction to the bone cement appeared good.

Collagen fibers ran parallel to the implant. The bone in the surrounding area was active and healthy, and in some areas the fibrous tissue had turned to bone: Microradiographs indicated tolerance of the metallic joint and bone cement, with incorporation by healthy granulation tissue, collagen fibers, and new bone to such an extent that a claim of complete biological acceptance of the implant by the natural tissue was justified.

This was the second report of animal studies with alloplastic TMJ devices since that of Ueno et al. [17]. In 1985 and again in 1990 Sonnenberg and Sonnenberg reported the use of total TMJ device consisting of a chromium-cobalt-molybdenum ramus condyle component that articulated against a UHMWPE fossa. In materials and geometric design, this device mimicked the alloplastic joint prostheses used by orthopedic surgeons. Between 1990 and 1995, other authors reported on the development and utility of alloplastic partial and total TMJ reconstruction prostheses. Indications for the application of these devices ranged from ankylosis to reconstruction after ablative surgery for disease or trauma in patients who had undergone multiple failed TMJ operations. Mercuri et al. [6], reported in 1995 on preliminary results with the use of a patient specific (customized), CAD/CAM*-produced total alloplastic TMJ reconstruction prosthesis in a prospective, limited clinical study.

The ramus component of this prosthesis was made of titanium; the condylar component made of Chromium-cobalt-molybdenum and the fossa component, made of titanium was backed with UHMWPE.

Indications for alloplastic joint reconstruction

Alloplastic joint reconstruction is a biomechanical rather than a biological solution to severe anatomic joint disease. The use of autogenous materials whenever possible is to be preferred. With these premises taken into consideration, the indications for alloplastic TMJ reconstruction are as follows:

Computer-assisted design/computer-assisted manufacturing. mercuri[633]

1. Ankylosis or re-ankylosis with severe anatomic abnormalities.

2. Failure of autogenous grafts in patients who had undergone multiple operations. It has been revealed that capillaries can penetrate a maximum thickness of 180 to 220 ~tm of tissue; scar tissue surrounding a multiple operated joint averages 440 ~tm in thickness, as stated by Robert Marx, DDS, in a 1994 speech. This may account for the clinical observation that autogenous tissue grafts, such as costochondral and sternoclavicular grafts, fail in the multiply operated patient. To survive, autogenous grafts need a rich vascular host site. The scar tissue that appears in the multiple operated patients does not provide an environment suitable to the success of an autogenous tissue graft.

3. Destruction of autogenous graft tissue by pathosis. Henry and Wolford reported less success with autogenous bone and soft tissue grafts in patients who had Proplast-Teflon in place.

4. Failure of Proplast-Teflon, causing severe anatomic joint mutilation. It is hard in such cases to adapt and fix autogenous materials to the crippled remnants of the ramus or fossa. In addition, the work of Henry and Wolford shows that reconstruction with autogenous materials is less predictable in such cases.

5. Failure of Vitek-Kent total or partial joints. Such failed joints usually cause a loss of residual fossa or ramus host bone, either because of a foreign body giant cell reaction; the latter can result from the presence of Proplast-Teflon on the medial surface of the ramus component or glenoid surface of the fossa components of the prostheses. This sort of joint failure results in a deformed anatomic condition; reconstruction with autogenous materials in such cases is difficult for the reason discussed in connection with indications 3 and 4. Furthermore, Linquist et al. described the erosion of the alloplastic condylar into the unreconstructed articular eminence or Glenoid fossa in 8 of 10 ramus condyle hemiarthroplasties for which Vitek ramus component prostheses had been used.

6. Severe inflammatory joint disease, such as rheumatoid arthritis, that results in anatomic mutilation of the joint components and functional disability. Patients with severe inflammatory joint disease typically have the best results with alloplastic joint replacement because they are used to the idea of joints being replaced as part of their disease; further, they have typically not undergone multiple operations in the same joint because of failure of treatment.

Relative contradictions to the use of alloplasts in the reconstruction of the TMJ

1. Insufficient patient age. Because these materials, unlike autogenous tissue, are static and have no potential for growth; the merits of using them in growing patients must be considered prudently.

2. Lack of understanding by the patient. Is the patient psychologically not ready to manage the permanent loss of a body part? Does the patient fail to comprehend that revision and/or replacement surgery in the future would be required? Does the patient have unrealistic hope of complete relief of pain and normal jaw function after alloplastic TMJ reconstruction. Lot of patients with functionless TMJs and who have undergone multiple operations need pre-reconstruction psychological counseling so that they understand and accept the limitations of further surgery, should they proceed.

3. Uncontrolled systemic disease, such as diabetes mellitus.

4. Allergy to the materials that are used in the device to be implanted.

5. Active infection at the implantation site.

Advantages and disadvantages of alloplastic joint reconstruction

Advantages

- Lack of donor site morbidity.
- Reduced intraoperative surgical time.
- A potential for decreased hospitalization.
- Limited fit of stock prostheses.
- Immediate functional ability without prolonged intermaxillary fixation.
- Allows maintenance of stable post-surgical occlusion because of no implant remodeling.
- The prosthesis can be planned to discourage heterotopic bone formation.
- Simultaneous rectification of retrognathia and apertognathia with rigid support from bilateral alloplastic prostheses.

Disadvantages

- Potential wear debris and related pathologic reactions.
- Prosthesis failure secondary to loosening of the screw or fracture of prosthesis from metal wear and tear.
- Cost of prosthesis.
- Unpredictable need for revision surgery.

Criteria for success of alloplastic joint replacement devices 6S

1. The materials from which they are made must be bio-compatible. Full discussion of this topic is not within the purview of this paper; such discussion can be seen in the orthopedic literature.

2. The device must be designed to withstand the loads delivered over the full range of function of the joint.

3. The device must be stable *in situ*. An unstable alloplastic prosthesis at the time of the implantation will fail. Movement of a reconstruction prosthesis under a functional or parafunctional load will result in the surrounding bone to degenerate, leading to further loosening of the device and ultimately to failure.

4. The surgery to implant the prosthesis must be carried out when the correct indications are present, and it must be done aseptically.

Table 1: Materials used.

Author	Year	Material used	Prosthesis type
Carnochan [9]	1840	Wood	Interpositional
Ridson [10]	1933	Gold foil	Interpositional
Eggers [11]	1946	Tantalum foil	Interpositional
Goodsell [12]	1947	Tantalum foil	Interpositional
Robinson [13]	1960	Stainless steel	Fossa
Christensen [14]	1963-1971	Chrome-Cobalt	Fossa
Morgan [16]	1971	Chrome-Cobalt	Fossa
Christensen [15]	1965	Vitalium with acrylic head	Condyle
Homsy [17]	1972	Chrome-Cobalt with proplast head.	Condyle
Morgan [16]	1973	Vitalium mesh with acrylic head	Condyle

Materials Used

In theory, the advantages of a successful alloplastic prosthesis are as under for adult patients (Table 1):

- Lack of donor-site morbidity
- Occlusal stability (compared with autogenous grafts, which have variable resorption rates)
- No requirement of inter-maxillary fixation
- Early range of movement with attendant dietary improvement.
- Reduced risk of ankylosis from Heterotopic bone formation
- Reduced surgical and anesthetic time

The unique position of the TMJ and its proximity to the temporal lobe of the brain make fixing a stock prosthesis difficult. Custom designed prostheses generated from CAD-CAM technology offer clear advantages, but they are costlier. These custom designed prostheses are especially useful in adult patients who had undergone several operations in which autogenous grafts have failed. In the beginning, alloplastic materials were used almost exclusively for recurrent ankylosis. Eggers applied tantalum foil in 1946 as an inter-positional implant. During 1960, Robinson applied a stainless-steel fossa prosthesis and Christensen used a formation of cast Vitallium fossae that were secured to the zygomatic arch.

Although several efforts were made to make a condylar prosthesis, the frequently used prosthesis were the AO-ASIF prostheses marketed by Synthes. This type of prosthesis was basically an extended reconstruction plate with a rounded condylar head. It was applied without a matching glenoid fossa implant. Surgeons used the prosthesis along with a Kent-Vitek (K-V) fossa.

The K-V fossa was developed in concert with the K-V condylar prosthesis. As both the above components used protoplast as a laminate, they were prone to foreign body reaction from polymeric debris. Although several authors reported long term successes with

the K-V system, it is no longer manufactured, largely because of problems associated with polytetrafluoroethylene. While removing this implant system, surgeons must be aware that the ramal prosthesis was fixed with a bolt and nut, with the nuts being placed on the medial surface of the inferior ramus. Surgeons has to be careful while removing all the protoplast, both from the superior surface of fossa implant and from the middle surface of the condylar strut.

In the latter part of 1980s, Boyne announced many joint replacements applying a Delrin (polyoxymethylene) head fixed to a titanium mesh plate. Although this method did not require a glenoid fossa prosthesis, some experts were concerned that the Delrin induced excessive heterotopic bone formation, leading to ankylosis. At present, the most extensively used alloplastic prosthesis is the Christensen prosthesis produced by TMJ, Inc. The Vitallium fossa implants have 0.5 mm thickness and available in 40 different sizes for the right and left sides. The implants are fixed to the eminence and lateral border of the zygomatic arch with 2.0 mm screws. Originally, matching condylar prosthesis was Vitallium with a methyl methacrylate head. Wide ranging experience with this prosthesis has shown excellent overall success rates. The type -1 Christensen condylar was associated with a 6% to 7% incidence of fracture; however, since the advent of the type-II Christensen condylar prosthesis, which has an expanded thickness and offset screw holes to avoid horizontal placement of the screws, the risk has reduced. Recently TMJ, Inc; has made the condylar prosthesis in an all-metallic version.

Because of its possible effect on the occlusion, correct positioning of any alloplastic joint prosthesis is very important. The patient must be placed in stable inter-maxillary fixation when the condylar prosthesis is being placed. The prosthesis has to be secured with two screws initially and then the mandible should be manipulated through range of movement to ensure that centric occlusion is achieved and the prosthesis does not subluxate or dislocate. Condylar prostheses are available in stock lengths of 45, 50, and 55 mm. The prosthesis should be secured with six to eight 2.7 mm screws, and care must be taken not to violate the neurovascular bundle in the inferior alveolar canal during placement of the anterior ramal screws. Generally, the application of a stock prosthesis like the Christensen can offer disadvantages. Because of variability in the contour of glenoid fossae, multiple fossa prostheses are available.

Even with this choice, surgeons frequently encounter difficulties in achieving proper fit in patients who had undergone multiple operations and have gross distortion of the normal joint anatomy. In view of this fact, a tailor-made prosthesis would be better. The designed Techmedica system was modelled based on a plastic skull fabricated on the basis of 3-dimensional computer tomographic scans. A titanium-mesh backing is tailor fitted against the glenoid fossa and a polyethylene articulating surface is connected to the titanium mesh.

A custom metallic condylar prosthesis is thereafter fixed to the lateral ramus. TMJ, Incorporation; is also manufacturing a custom fossa and condylar complete joint prosthesis from 3-dimensional computer tomographic data.

With any complete joint alloplastic system, the patient is capable of only rotational movement because no lateral pterygoid insertion is present to provide protrusive motion. Because 32 and 35 mm of intra-incisal opening is a reasonable belief for range of movement with a total joint prosthesis. Unilateral replacement results in deviation to the side of the prosthesis on terminal opening. Reduction of pain for patients who have undergone multiple operations is also a justifiable expectation; there is a direct correlation between the number of previous surgical procedures and the likelihood that pre-surgical symptoms will be reduced. As on date, no long-term data have been compiled on the subject of alloplastic implant systems available at present.

Orthopedic experience indicates that these implants systems may have a useful life span of ~7 to 10 years. With advances in bio-materials and clinical understanding of necessary design modifications, this figure should increase. Complications that are specific to alloplastic joints comprise of the following; prosthesis displacement or fracture, foreign body reaction to polymeric or metallic debris, heterotopic bone formation (which results in ankylosis of the prosthesis) and impairment to the inferior alveolar nerve by screw placement. The facial nerve may be damaged during placement of the prosthesis, but this risk is associated with all joint procedures.

This author is currently involved in a clinical trial of a prosthesis developed by Biomet-Lorenz. The prosthesis consists of a high-molecular-weight polyethylene fossa that is secured to the zygomatic arch by 4 self-tapping 2.0-mm screws. The fossa prosthesis is a stock prosthesis and the articular eminence surface is flattened before fitting begins. A clear Lucite impression is used to obtain a tripod effect, imparting stability to the fossa prosthesis.

Once the prosthesis is firm, a small portion of methacrylate cement is applied to fill the voids between the fossa prosthesis and the glenoid fossa. The cement should never be used as a load bearing surface. It is mechanically attached to the fossa with a small dowel protruding from the inner surface of the fossa. The methyl methacrylate is treated outside the body to avoid any excess heat against the glenoid fossa. After the fossa is fixed, the patient is placed in inter-maxillary fixation and the chrome-cobalt condylar prosthesis is fitted. The components are planned to optimize contact between the condyle and the fossa. The axis of rotation is brought inferiorly and the deep concavity in the glenoid fossa is planned to permit pseudotranslation of the condylar prosthesis at the time of opening. This design modification has improved the maximum interincisal opening by approximately 15% to 18%. Preliminary results are very encouraging but not conclusive at this stage.

Transport distraction osteogenesis for reconstruction of the ramus-condyle

The application of transport Distraction Osteogenesis (DO) in Temporo-Mandibular Joint (TMJ) reconstruction. It is a very useful technique that provides an alternative to autogenous bone grafting and prosthetic total joint replacement in reconstruction of the Ramus Condyle Unit (RCU). Transport DO takes advantage of a curious phenomenon that was first observed by Llizarov [3] and later confirmed in animal studies [4,5] new bone formation at the trailing edge and cartilage formation at the leading edge of a transport disc. This procedure is appropriate for cases in which there is sufficient remaining bone to create a transport disc after all pathology has been removed.

Creation of transport disc and distractor placement

The ramus of the mandible is approached through an incision beneath the angle (Figure 1). The entire lateral ramus and angle are exposed, with the surgeon taking care to maintain all muscle and periosteal attachments on the medial aspect of the ramus. The teeth are placed in occlusion, and an “I” osteotectomy is outlined on the

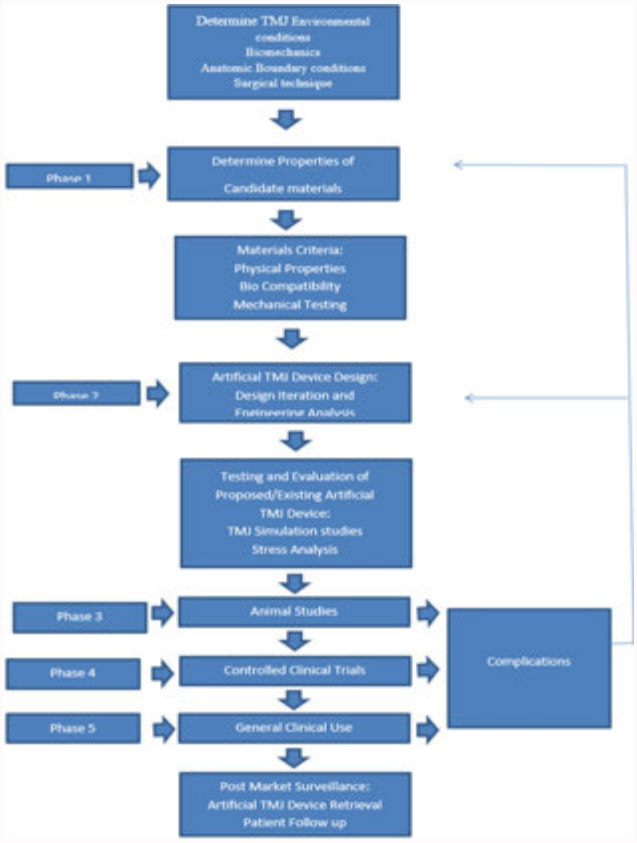

Figure 1: Determine TMJ.

remaining posterior ramus and angle (Figure 1). The bone contained within the "I" will become the transport disc. The vertical limb of the L is designed to parallel a vector that will bring the disc into the glenoid fossa (arrow). This limb is placed 12 mm to 15 mm from the posterior border to avoid injury to the inferior alveolar nerve. The dimension of the disc will vary, depending on the amount of pathology that has been removed. A small part of the osteotomy is not completed at this time so that the disc will remain stable while the distractor is placed. The leading edge of the disc is rounded, if this has not been already done as explained previously.

An L osteotomy in the posterior ramus outlines the transport disc. It is not completed at this time to facilitate placement of the distractor. The leading edge is rounded to form the future articular surface. The vertical limb parallels the vector that will take the disc into the glenoid fossa (arrow).

An end-driven distractor is used. The superior attachment plate (for the transport disc) is detachable for ease in later removal. The activation arm is also detachable for ease in placement and removal.

An end-driven, internal distractor is used (KLS Martin LP, Jacksonville, FL.) This device has 2 types of interchangeable, detachable attachment plates for the transport disc: A fixed rectangular attachment plate for the main portion of the mandible and a detachable activation arm (Figure 1). Depending on the length of the RCU to be reconstructed, an appropriate distractor is chosen. The best locations for the attachment plates are determined. If the L osteotomy is close to the inferior border, the inferior plate should be positioned anteriorly.

The attachment plates are cut and bent to fit the ramus. The distraction vector is checked and the distractor is attached with at least 3 screws in each plate. The activation arm is brought into the neck through a small stab incision below the submandibular incision and attached to the distractor.

Because the transport disc is now stabilized, the L osteotomy is completed. Dead space is obliterated, usually with a fat graft or with a temporalis flap.

The vector of distraction is determined, and a single screw is placed in the superior plate (on the transport disc). The vector is adjusted if necessary, and at least 3 screws are then placed in each plate (Figure 1). Monocortical screws are used if they overlie the inferior alveolar nerve; otherwise, bicortical screws are used. Dividing the portion of cortex that was left intact to stabilize the transport disc completes the L osteotomy. This is done with a saw or by inserting a periosteal elevator and twisting. The activation arm is brought through the skin of the neck *via* a stab incision below the sub-mandibular incision. It is attached to the distractor.

The distractor is opened several turns to ensure that the transport disc moves freely. It is closed once again. Dead space is obliterated. All incisions are closed. These procedures are performed with the patient under general anesthesia. We discharge all patients from the hospital the morning after surgery.

Latency and distraction

No distraction is carried out for a 7-day latency period. Normal postoperative wound care is performed. The site is where the activation arm penetrates the skin is covered with antibiotic ointment and a bandage. Perioperative antibiotics are given, but there is no need for postoperative antibiotics. The patient is placed on a soft diet and performs range-of-motion exercises. This is especially important in patients being treated for ankylosis and other forms of hypomobility. At the conclusion of the latency period, distraction of 0.5 mm (1 complete turn of the distraction arm) is performed twice daily. The length of the RCU that is being reconstructed can provide an indication of the total distraction period. There will be some variability, because of differences in the compressibility of the tissues interposed between the transport disc and the glenoid fossa. Imaging at this stage will not show bone in the distraction gap (Figure 1). Distraction is concluded when the occlusion returns to normal. Some patients will "self-correct" their occlusion with the muscles of mastication. When the patient reports that the bite "feels normal", it is important for the clinician to check it by placing the mandible in retrusion. Overcorrection has not proven to be necessary. Patients with a pre-existing malocclusion undergo distraction to a predetermined occlusion (the occlusion from which orthodontics and/or orthognathic surgery will be carried out). This position is maintained.

After a 7-day latency period, the transport disc is distracted 0.5 mm twice daily. As the disc moves into the glenoid fossa, tissue in the dead space is compressed. Callus in the distraction gap has not yet ossified. The occlusal surfaces of selected teeth during consolidation. When distraction has been completed, the skin is pushed back and the distraction arm is cut short with a heavy wire cutter. The skin quickly closes, so there is little chance of infection. Although the arm is detachable, it cannot be completely removed at this stage. Continuous range-of-motion exercises are important, especially for hypomobility patients.

Consolidation

The regenerated bone is allowed to consolidate for at least 3 months before the distractor is removed. During this time, the distractor acts as an internal fixation device. The diet is slowly advanced to normal. Range-of-motion exercises are continued. The distractor can be removed very rapidly through the original submandibular incision. After it is exposed, it is turned in reverse for several millimeters. This detaches it from the superior attachment plate. The superior plate has been transported far from the incision and is not removed. The remainder of the distraction arm is detached. All screws are removed from the inferior attachment plate, and the device is removed (Figure 1). This procedure is performed with the patient under general anesthesia on an outpatient basis. Orthognathic surgery, when necessary, is deferred for 6 months.

Conclusion

Experienced Surgeons can accomplish convincing results with autogenous reconstruction or alloplastic reconstruction of the temporomandibular joint. Costochondral grafting is clearly the procedure of choice in growing patients, but a predictably successful, safe and effective alloplastic prosthesis offers larger advantages for reconstruction of the severely dislocated joints in adult patients. When available data confirm the effectiveness of an existing model or one that is yet to be developed, surgeons will have a choice between equally effective autogenous and alloplastic techniques. The final decision will be based on the specific requirement of the patient.

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