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## TMJ Prostheses for Condylar Resorption and Benign Tumors Affecting the Condyle

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Received February 13, 2025.

Accepted for publication July 9, 2025.

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The authors report no conflicts of interest.

**Supplemental Digital Content is available for this article. Direct URL citations are provided in the HTML and PDF versions of this article on the journal's website, www.jcraniofacialsurgery.com.**

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ISSN: 1536-3732

DOI: 10.1097/SCS.00000000000011756

**Abstract:** Total mandibular joint replacement is a clinical strategy to treat severe temporomandibular joint (TMJ) disease. The use of TMJ prostheses was introduced into clinical practice in 1960; however, after approval by the FDA in the 1990s, its use became a regular technique for treating some TMJ diseases. Current TMJ prostheses include a fossa component and a condylar component and can be stock or custom-made. Procedures to implant the prosthesis and replace the TMJ are complex; however, technological improvements in planning have improved the process and outcomes. Despite improved knowledge of TMJ replacement, controversy remains regarding indications and timing of the technique. This narrative review aims to describe the indications, characteristics, and variables in TMJ replacement in clinical conditions related to condylar destruction or condylar overgrowth in the case of benign tumors.

**Key Words:** Temporomandibular joint, TMJ disease, TMJ prosthesis, TMJ replacement

**T**emporomandibular joint (TMJ) replacement is used in some clinical conditions relating to changes in morphology, such as malformation and deformity, as well as changes in TMJ function. End-stage TMJ disease is usually included as an indication for TMJ replacement.<sup>1</sup>

Reduction in mandibular condyle size and volume is associated with some diseases as arthritis, which can be osteoarthritis or autoimmune disease (rheumatoid arthritis or juvenile arthritis).<sup>2</sup> Osteoarthritis is characterized by condylar head volume reduction, impacts up to 90% of individuals over 65 years old.<sup>3</sup> Condylar resorption following orthognathic surgery, idiopathic condylar resorption (ICR) in cases without identifiable factors,<sup>4</sup> and other autoimmune disorders such as psoriatic arthritis and ankylosing spondylitis also have been related to condyle reduction.

The common clinical feature with loss of condylar volume is class II facial morphology with or without facial asymmetry from mandibular clockwise rotation. Furthermore, patients experience mandibular retrognathia, loss of occlusal balance and function, reduced airway volume, increased submandibular soft tissue laxity, and reduced posterior vertical facial height.<sup>5,6</sup> A change in bone density of the mandibular condyle is observed with interruption in cortical lines, and relevant symptoms include as pain, chewing difficulty, joint noises, and limited mouth opening (end-stage TMJ disorder).<sup>7</sup>

On the other hand, there are several benign lesions that can affect the TMJ causing overgrowth of the mandibular condyle in terms of both volume and size. Such benign lesions can include cystic lesions or tumors, including osteoma, osteoblastoma, osteochondroma, chondroma, chondroblastoma, and nonossifying fibroma as well as hemangioma or chondroid tenosynovial giant cell tumor.<sup>8</sup> Clinical signs commonly include impaired temporomandibular function and mobility, dentofacial deformity, or facial and/or occlusal asymmetry. Treatment typically involves surgical resection, with total TMJ replacement frequently required for cases of irreversible damage. Over the years there have been many reported TMJ reconstruction methods with both autologous materials, such as costochondral grafts, and alloplastic materials.<sup>9</sup> Alloplastic reconstruction methods have gained support recently with success reported in TMJ reconstruction in cases of severe pathology, including congenital TMJ abnormalities, neoplasia involving extensive resection as well as severe inflammatory or degenerative TMJ disease.<sup>10</sup>

This narrative review aims to describe the indications, characteristics, and variables in TMJ replacement in clinical conditions related to condylar destruction or condylar overgrowth in the case of benign tumors.

## MATERIALS AND METHODS

A brief review was conducted to describe the clinical reports related to TMJ prosthesis in mandibular condyle reduction and mandibular condyle augmentation using PubMed, Lilacs, Cochrane, and Scopus databases to March 2023. The following search strategy was used: (a) (temporomandibular joint replace or temporomandibular joint prosthesis or artificial temporomandibular joint) and (condylar resorption or TMJ osteoarthritis or temporomandibular joint osteoarthritis or TMJ-OA or TMJ arthritis or temporomandibular joint arthritis or condylar degeneration); (b) benign lesions temporomandibular joint and total joint replacement or condylar hyperplasia and temporomandibular joint and total joint replacement or osteochondroma and temporomandibular joint and joint replacement or tumor and temporomandibular joint and joint replacement or cyst and temporomandibular joint and joint replacement.

Studies published in English that included outcomes of patients undergoing TMJ replacement of one or more joints were included in the review. Case reports, case series, and original research involving patients with a diagnosis related to reduction or augmentation of the mandibular condyle were included.

The titles and abstracts were screened independently by 2 investigators for eligibility. In case of discrepancy, consensus was reached by discussion or consultation with a third reviewer. The software Mendeley 2.80.1 (Reference Management, Elsevier, London, England) was used to perform the final review. Data included: authors, study design, sample, number and type of TMJ prosthesis, follow-up, pain, and mandibular function. Additional indications such as trauma, ankylosis, and treatment of malignancies will be covered in a second narrative review.

## Total TMJ Replacement in Cases With Condylar Size and Volume Reduction TMJ Replacement in Rheumatoid Arthritis and Degenerative Disease

Rheumatoid arthritis (RA) has a prevalence of 1%, affecting women more than men at a 3:1 ratio and an age between 35 and 45 years old. The TMJ is affected in 5% to 86% of patients with RA, particularly in its severe form.<sup>11</sup> In a series of 1600 patients with RA, 25% had at least one joint replaced, which included the TMJ. Concerning the TMJ, over 90% of patients with RA can maintain adequate quality of life with nonsurgical measures (eg, medications) or minimally invasive procedures, such as arthrocentesis. However, a smaller percentage of patients do not respond adequately to minimally invasive treatments and require prosthetic joint reconstruction.

In 2019, an international Juvenile Idiopathic Arthritis (JIA) working group (TMJaw) proposed an algorithm for surgical treatment of the TMJ, noting that disease progression, skeletal maturity, and severity of dentofacial deformity are variables that should be considered for surgical treatment.<sup>12</sup> Mehra et al<sup>13</sup> reported outcomes of 15 patients treated with TMJ replacement diagnosed with RA between 15 and 61 years old with an average follow-up of 34 months. In 10 cases maxillary osteotomy was included in the same operation. All objective and subjective analyses improved significantly after TMJ prosthesis implantation.

In other retrospective study<sup>14</sup> with 71 patients undergoing prosthetic reconstruction of the TMJ with at least 1 year of follow-up, were included 21 with TMJ osteoarthritis, 10 with rheumatoid arthritis, 3 with psoriatic arthritis, and 2 with ankylosing spondylitis. There was an average of 2 previous surgeries between 0 and 12 TMJ surgeries, before joint replacement. Prosthesis dislocation was the most reported complication, and 2 patients required a transfusion due to blood loss. In this study 71 of the 74 patients were satisfied with the joint replacement surgery. Gruber et al<sup>15</sup> prospectively evaluated outcomes of 58 patients undergoing prosthetic TMJ replacement over a 3-year follow-up and 26 patients over a 5-year follow-up period for varying arthritis, including 7 patients with rheumatoid arthritis, 4 with psoriatic arthritis, and 15 with a degenerative disease. All patients reported pain reduction and improvement in all parameters measured in the first year, with stability at 3 and 5 years of follow-up.

O'Connor et al<sup>16</sup> prospectively assessed prosthetic TMJ replacements in 26 patients (2 bilateral) with inflammatory arthritis (RA, psoriatic arthritis, and ankylosing spondylitis). The authors reported significant improvements in subjective and objective outcomes. In a retrospective study, Sahdev et al<sup>17</sup> reported outcomes of 95 patients treated with TMJ prostheses over 15 years. The diagnosis was inflammatory disease in 23% of the patients and degenerative TMJ disease in 19%, with an average age of 44 years. The time from diagnosis to prosthesis implantation ranged from less than 1 year to 45 years. In terms of complications, the common complications were related to facial nerve alterations at the surgical site, and the authors highlighted how psychological variables significantly impact the recovery in postoperative pain.<sup>17</sup> However, most of the articles showed no complications regardless of the TMJ prosthesis and the activity of the prosthesis for a long time<sup>18,19</sup> (Supplemental Table 1, Supplemental Digital Content 1, <http://links.lww.com/SCS/I213>).

### TMJ Replacement in Idiopathic Condylar Resorption

Idiopathic condylar resorption is an acquired TMJ disorder that results in loss of condylar volume, clockwise rotation of the mandible, and anterior open bite. Some authors have suggested that mechanical overload of the TMJ or reduced vascular supply in the condyle may be associated factors.<sup>20</sup> Reduced levels of estradiol and the use of contraceptives may also be associated with ICR. Nonsurgical treatment of the TMJ shows low predictability;<sup>20</sup> significant recurrence during follow-up has also been seen with treatments such as only orthognathic surgery.<sup>21</sup> Temporomandibular joint surgical techniques, such as joint disc surgery, could be useful in the early stages of ICR.<sup>22</sup> In contrast, in advanced stages of ICR, it is suggested that reconstructive techniques, such as autogenous (eg, costochondral rib grafting) or TMJ prosthesis, could be used.

Only one article analyzed patients with ICR treated with a TMJ prosthesis<sup>23</sup> reporting outcomes of 26 patients with ICR (mean age 26 y) that underwent mandibular advancement with TMJ prostheses. A concomitant Le Fort I osteotomy was performed in 76% of patients. All objective and subjective variables improved significantly until the end of follow-up (1 y), highlighting an important question about the early age (26 y old) for the use of the prosthesis and the probability of replacing the prosthesis in the future<sup>24</sup> (Supplemental Table 2, Supplemental Digital Content 1, <http://links.lww.com/SCS/I213>).

### TMJ Replacement in TMJ Osteoarthritis

Temporomandibular joint replacement for TMJ osteoarthritis was evaluated in 2 publications (Supplemental Table 3, Supplemental Digital Content 1, <http://links.lww.com/SCS/I213>). Zheng et al<sup>25</sup> treated 12 patients with end-stage osteoarthritis with customized unilateral prostheses after failed nonsurgical treatment. There was no mention of adjunctive orthognathic surgery. The prosthesis effectively improved subjective and objective conditions in every patient, thereby confirming its efficiency in morphologic and functional stability.

Kanatsios et al<sup>26</sup> compared stock and customized prosthetic systems in 117 patients (mean age 53 y) with end-stage TMJ disease due to osteoarthritis over a minimum 2-year postoperative period. In almost 50% of cases, there was failed surgical treatment before prosthetic replacement. Significant improvement in all the evaluated parameters was noted in the cases of stock and customized prostheses.

### TMJ Replacement in Juvenile Idiopathic Arthritis

As many as 87% of patients with JIA with TMJ involvement are asymptomatic, although progressively reduced mouth opening and painful mandibular mobility may be observed.<sup>27</sup> JIA can result in reduction in condylar height, mandibular condyle flattening, articular disc degeneration, and malocclusion,<sup>28</sup> requiring reconstructive treatment to achieve better anatomic and functional conditions. Supplemental Table 4, Supplemental Digital Content 1, <http://links.lww.com/SCS/I213> shows studies in this area involving TMJ prostheses.

A study<sup>29</sup> was conducted on 20 patients with end-stage JIA of the TMJ treated with a TMJ prosthesis (16–23 y old) one patient received bilateral prostheses, and 55% received prostheses with orthognathic surgery. On average, the patients had 8.5 years of treatment with a rheumatologist. All the parameters evaluated showed improvements at follow-up, both pain and jaw mobility.

Trivedi et al<sup>30</sup> published a retrospective study of JIA patients treated with orthognathic surgery compared with those treated with total TMJ prosthesis and orthognathic surgery. The TMJ prosthesis with orthognathic surgery group comprised 40 patients, of which 32 were women. The average age of the group was 17.5 years old, ranging between 13 and 64 years old. In this group, 34 patients were under 25 years old; the average duration of follow-up was 24 months; 26 patients were included in the control group, and the average age was 35 years old. In the TMJ replacement with orthognathic surgery group, in every analysis, a significant improvement was noted, including a decrease in TMJ pain, a reduction in headache, an improvement in mandibular function, and an increase in mouth opening. They conclude that the presence of this disease is frequently associated with facial deformity, and its treatment with prostheses may be beneficial using a combined approach with orthognathic surgery. The same group<sup>31</sup> published a retrospectively analyzed on 42 patients with JIA treated with a custom TMJ prosthesis and orthognathic surgery between 1991 and 2019. The minimum age at intervention was 14 years in females and 16 years in males. The mandibular advancement was ~15 mm and there was no relapse. These findings confirm the stability of movement using mandibular and maxillary surgery combined with TMJ prostheses.

### Total TMJ Replacement in Cases of Benign Tumor

#### Total TMJ Replacement in Patients With Osteoma

Osteoma is a benign tumor composed of mature bone tissue that occurs uncommonly in the TMJ. Clinical symptoms in-

clude pain, limited joint movement with trismus, facial deformity, and malocclusion.<sup>32</sup> Surgical resection is the treatment of choice. A reliable TMJ reconstruction consists of a one-stage alloplastic total TMJ replacement. Case reports (Supplemental Table 5, Supplemental Digital Content 1, <http://links.lww.com/SCS/I213>) describe an improved quality of life, improved mouth opening as well as pain relief.<sup>33–35</sup>

### Total TMJ Replacement in Patients With Osteochondroma

Osteochondroma is a common benign tumor affecting the mandibular condyle. Temporomandibular joint osteochondroma can result in facial asymmetry, pain, malocclusion as well as limitation in mouth opening. The etiology of the disease is not fully elucidated but has been reported to be associated with facial trauma, hormonal growth, and genetic factors.<sup>36</sup> As of 2011, there were 108 total reported cases in the English literature, of which only 2 were treated with a total TMJ prosthesis.<sup>36</sup>

Treatment modalities included tumor mass excision, condyloplasty, and total condylectomy. Some clinical cases showed the use of the TMJ replacement in cases with osteochondroma,<sup>37–40</sup> reporting good results in term of TMJ function, mandibular balance, and facial symmetry. More than 10 subjects in sample were presented by 2 articles<sup>23,35</sup> showing a good outcome in objective or subjective analysis. The treatment with alloplastic system to replace the TMJ can be planned with maxillomandibular osteotomy to promote complete facial treatment in one surgical time (Supplemental Table 6, Supplemental Digital Content 1, <http://links.lww.com/SCS/I213>).

### Total TMJ Replacement in Patients With Ameloblastoma

Ameloblastoma is an epithelial odontogenic tumor, representing 1% to 3% of all cysts and tumors of the maxillomandibular region with a high tendency to recur. Treatment strategies range from enucleation, in cases of unicystic ameloblastoma, to en bloc resection.<sup>41</sup> While the tumor often spares the condyle, achieving adequate margins in tumors affecting the ramus often require disarticulation. Reconstruction includes the use of autologous bone grafts with combined or sole alloplastic TMJ reconstruction.

Current reports using custom or stock prostheses show valid and predictable results in the reconstruction of large TMJ defects after resection, resulting in pain relief, improved mouth opening, and a reliable esthetic outcome<sup>42–45</sup> (Supplemental Table 7, Supplemental Digital Content 1, <http://links.lww.com/SCS/I213>).

Clinical cases showed the advantage to use the alloplastic replacement with a customized strategy; in all the cases were obtained stability in the TMJ and a predictable position of the maxillomandibular complex; the mirroring image was used for prosthesis design to create symmetry in the reconstruction.<sup>42,43,45</sup> Subash et al<sup>44</sup> presented a case series demonstrating the long-time follow-up for at least 4 years showing functionality in regular processes, like mastication and swallowing; quality of life show a significant improvements in the patients.

### Total TMJ Replacement in Patients With Odontogenic Keratocyst

Odontogenic keratocysts account for ~12% to 14% of all odontogenic cysts of the jaws and have distinctive histopathology findings. Radiographically, the lesions present most often uni- or multilocular radiolucency, surrounded by smooth or

scalloped margins with sclerotic borders.<sup>46</sup> Enucleation results in high recurrence rates. Extension of odontogenic keratocysts into the condylar head may ultimately require TMJ reconstruction after removal of the lesion.

The outcomes of total alloplastic TMJ replacement in the reported patients (Supplemental Table 8, Supplemental Digital Content 1, <http://links.lww.com/SCS/I213>) demonstrated lower pain score, adequate mouth opening as well as stable occlusion, good facial symmetry, and high patient satisfaction.<sup>44</sup>

### Total TMJ Replacement in Patients With Synovial Chondromatosis

Synovial chondromatosis is a benign disease characterized by a nodular cartilaginous proliferation arising from the joint synovium, bursae, or tendon sheaths. Clinical symptoms include swelling, pain, headache, crepitation, malocclusion, and joint dysfunction possibly mimicking other nonspecific TMJ diseases, which can easily lead to a delay in diagnosis or a misdiagnosis.<sup>47</sup>

There is only existing case report of an alloplastic TMJ replacement in a patient with synovial chondromatosis.<sup>48</sup> As more noninvasive treatment options, such as open joint arthroplasty with disc preservation have become available, TMJ replacement has not been necessary (Supplemental Table 9, Supplemental Digital Content 1, <http://links.lww.com/SCS/I213>).

### Total TMJ Replacement in Patients With Chondroid Tenosynovial Giant Cell Tumor

Tenosynovial giant cell tumor is a rare benign proliferative disorder of the synovium. The etiology of this locally aggressive and proliferative tumor involves both inflammatory and neoplastic processes.<sup>49</sup> Imaging reveals joint space effusion, multiple low-signal intensity foci within the fluid, and extensive erosions within the glenoid fossa, articular eminence, and root of the zygoma. Due to the aggressive and locally destructive nature of tenosynovial giant cell tumor, surgical resection of affected tissue with clear margins is the treatment of choice.

Total TMJ prosthesis seems to be a reasonable treatment option in patients with extraarticular spread;<sup>50</sup> however, most reported cases did not show any reconstruction.<sup>51</sup> Reconstruction may include autogenous grafts bone, such as costochondral graft,<sup>52</sup> to total joint prosthetic replacement,<sup>50</sup> and cases treated with TMJ prosthesis showed good results in term of function, stability, and reconstruction<sup>51,53</sup> (Table 10, Supplemental Digital Content 1, <http://links.lww.com/SCS/I213>).

## DISCUSSION

Temporomandibular joint replacement has been indicated in patients with end-stage disease in the form of volume loss of the mandibular condyle or in overgrowth due to tumor. The therapy shows clear and sequential analysis; regardless of the cause of the joint replacement, very similar routine and complications occur.

Peres Lima et al<sup>54</sup> published a systematic review and meta-analysis in 2023 summarizing the most common complications of total TMJ replacement. Paresis or paralysis of the facial nerve branches, followed by sensory alterations and heterotopic bone formation were the most prevalent complications.<sup>54</sup> In addition, in 2020 a survey among oral and maxillofacial surgeons reported that the incidence of TMJ replacement revision (keeping the same device) was 3% and replacement (placing a new device) was 4.9% due heterotopic ossification (27.5%). Additional studies reported explanation due to instability of the implant from screw loosening or metal hypersensitivity,<sup>55</sup>

postoperative open bite due to maxillary artery hemorrhage,<sup>56</sup> and reankylosis of the TMJ prosthesis.<sup>19</sup>

Reduction in mandibular condyle volume and size can result from increased catabolism of the condyle and disc displacement and destruction due to autoimmune and acquired diseases.<sup>1</sup> Most patients with end-stage condylar volume reduction develop jaw deformities with implications in functional elements such as breathing, mastication, and occlusion.<sup>6</sup> Subjectively, it is possible to observe pain and functional difficulty at various levels.<sup>57</sup> Most studies included in this review report on the terminal condition of the TMJ, which demonstrates the total loss of morphology and function of the joint; in some cases, a TMJ prosthesis was implanted after some nonresolving joint surgeries.

Temporomandibular joint replacement is intended to reduce or eliminate pain symptoms, increase mouth opening, improve mastication, and restore the posterior vertical height of the mandible.<sup>57,58</sup> Due to facial deformity, patients may have TMJ prosthetic reconstruction along with orthognathic surgery. Wolford et al<sup>22</sup> showed that joint replacement improved all objective and subjective parameters assessed during 5 to 8-year follow-up of patients with various joint pathologies, including TMJ arthritis.

In this review of a variety of pathologic entities related to condyle reduction, >250 patients were reported to have improved quality of life. Temporomandibular joint replacement has been demonstrated to be an efficient and effective method for managing condylar volume loss often after failure of non-surgical or minimally invasive surgery techniques.<sup>59</sup> In cases of TMJ tumor, orthognathic surgery and concomitant TMJ replacement were not commonly reported; however, they are reasonable strategies when it is necessary to restore the function of the TMJ and maxillofacial deformity.

One of the relevant questions raised in this review may be around the age of the patients. Individuals with RA, ICR, and JIA who are under the age of 30 may require joint replacement surgery to restore facial morphology and occlusion. Long-term follow-up is required to document the longevity of these prostheses. It appears that TMJ replacement can be performed in young patients for condylar volume loss; however, long-term studies are needed.

In terms of reconstruction in cases of tumor and condylar size augmentation, alloplastic custom-made joints allow for a precise anatomic and esthetic reconstruction avoiding donor site morbidity, and reducing intraoperative time relative to autogenous grafts.<sup>35</sup> Although fewer cases have been reported, use of prosthetic replacement for benign lesions affecting the condyle provides reliable esthetic and functional outcomes with improved mouth opening, stable occlusion, and a reduction in pain. The major disadvantages are the unknown life expectancy of the devices as well as the possibility of a giant cell foreign-body reaction and implant loosening. New research it is necessary to clarify these ideas relative to evaluate the long-time follow-up of this treatment.

Overall, the current review found positive outcomes after removal of benign TMJ lesions and reconstruction with alloplastic total joint prosthesis. However, most benign lesions of the TMJ can be removed without sacrificing the condylar head, so joint replacement may only be required with extensive TMJ lesions.

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## A Study on Gender Differences in the Maximum Attractiveness Values for Cephalometric Measures