

RESEARCH

Open Access



# Modified minimally invasive surgery in reconstructing the temporomandibular joint disk by transplantation of the temporalis myofascial flap

Chen-xi Li<sup>1\*</sup>, Peng Yu<sup>1</sup>, Zhong-cheng Gong<sup>1\*</sup> and Xu Liu<sup>2</sup>

## Abstract

**Objective** The transplantation of temporalis myofascial flap (TMF) is an indispensable method to treat severe temporomandibular joint disorders with disk failure. How to select the indication and the ways of transplantation is still a challenging topic for achieving the ideal effect. We reported the new methods and follow-up results of the patients treated with pedicled TMF transplantation.

**Methods** Retrospective case series was performed at Temporomandibular Joint Specialist Clinic, the First Affiliated Hospital of Xinjiang Medical University, from December 2014 to August 2022. 39 patients (50 sides) included anterior disk displacement without reduction and disk perforation who underwent discetomy and immediate reconstruction with pedicled TMF. The initial and postoperative maximum mouth opening (MMO), and pain visual analogue scale (VAS) were compared via paired *t*-test and Wilcoxon signed-rank sum test, respectively.

**Results** The average of follow-up time was 30.07 months. The reconstructed temporomandibular joints basically achieved stable occlusion, good function, and satisfactory effect. The patients displayed a remarkable reduction of VAS score of pain, and improvement of the MMO compared with that before operation ( $P < 0.001$ ). MR scanning revealed the grafts in joint space showed band-shaped soft tissue density of medium signal and had the clear edges, without interruption and fragment.

**Conclusion** Reconstruction of the temporomandibular joint disk by transplantation of the TMF applying modified minimally invasive surgery was a feasible method, which could improve the function of joints and prevent adhesion, without obvious complications in donor region.

**Keywords** Temporomandibular joint disorders, Pedicled temporalis myofascial flap, Microsurgical repair and reconstruction

\*Correspondence:

Chen-xi Li  
lichenxiuke@gmail.com  
Zhong-cheng Gong  
gump0904@aliyun.com

<sup>1</sup> Department of Oral and Maxillofacial Oncology & Surgery, The First Affiliated Hospital of Xinjiang Medical University, School/Hospital of Stomatology Xinjiang Medical University, Stomatological Research Institute of Xinjiang Uygur Autonomous Region, No.137 Liyushan South Road, Urumqi 830054, People's Republic of China

<sup>2</sup> Department of Maxillofacial Surgery, Hospital of Stomatology, Key

Laboratory of Dental-Maxillofacial Reconstruction and Biological Intelligence Manufacturing of Gansu Province, Faculty of Dentistry, Lanzhou University, Lanzhou 730013, People's Republic of China



© The Author(s) 2023. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

## Introduction

Temporomandibular joint disorders (TMD) is a set of conditions affecting the jaw joints and surrounding muscles and ligaments, which can be caused by psychological factors, an improper bite, bruxism (teeth grinding/clenching), acute trauma, arthritis or wear and tear [1, 2]. There is also evidence that TMD may be related to cervical spine disorders and its mobility [2]. Although sleeping problems have been hypothesized as an etiological or risk cofactor, the degree to which it plays a role has not been definitively delineated [3, 4]. The prevalence of TMD ranges from 15 to 54% in different populations, and most affected individuals can present with characteristic symptoms such as clicking, joint pain, limited range of mouth opening, masticatory difficulty, mandible dysfunction, *etc* that the peak of the development of the symptoms is between 20 and 40 years of age [5, 6]. Recurrent attacks of severe chronic TMD many times may result in the degeneration/ derangement of articular disk, so as to further lead to functional morbidity like compromised speech, mastication, and deglutition, and even unaesthetic outcome in poor situation [7–9].

The temporomandibular joint (TMJ) disk (also called meniscus) is comprised of fibrocartilage, with crimped collagen, reckoned to better absorb impacts. On the one hand, the disk itself locates between the condyle of the jaw and mandibular fossa, merely comprising coarse non-vascular connective cells; therefore, disk displacement/peroration will occur when the biochemical and biomechanical loads tremendously exceed the normal levels that the temporomandibular disk can withstand [10–12]. On the other hand, it is characterized by a biconcave shape with a thicker periphery attached to the TMJ capsule and divides the joint into two compartments [8, 12]. Hence reconstruction of such sophisticated structure after ablative surgery is more challenging. Various loco-regional and free flaps and kinds of artificial biomaterials have been reported in extant literature nonetheless still an ideal reconstruction option for such structure is under research.

Except that no need to consider its biocompatibility, temporalis myofascial flap (TMF) seems to be one of the optimal choices among all other regional flaps since it is a locally available, reliable and safe flap characterized with abundant blood supply, adequate bulk and its anatomical site is near to damaged disk [13]. The purpose of this study was to investigate the efficacy of the TMF as an interpositional component transplanted for the reconstruction of TMJ disk. Many previous investigators have examined the use of TMF in TMJs that had assorted forms of existing pathological conditions such as congenital anomalies, autoimmune arthritides, degenerative joint disease, traumatic defects, lateral capsule

flaccidity, ankyloses, as well as in those with prior alloplastic implants and autogenous grafts [14]. In this investigation, the TMFs were studied exclusively in patients whose joints had formerly been treated with conservative therapy and without any surgeries. This present study analyzed both preoperative and postoperative subjective and objective findings in TMD patients.

## Patients and methods

At first, fifty-two consecutive TMD patients from December 2014 to August 2022 constituted the population of this study. By accessing medical record files, in total, thirty-nine patients composed of 5 males and 34 females were selected for the present study. Among them, 28 patients underwent unilateral TMF procedures and 11 patients underwent bilateral TMF procedures (Table 1). A flow diagram describing the subjects' enrollment as well as the next working plan is given in Fig. 1.

The mean age was  $45.33 \pm 12.33$  ranging from 23 to 67 years old, and the male-to-female ratio was 1:6.8. All patients only received conservative interventions previously, and had no history of TMJ surgery. Interventions included patient education, exercise, manual therapy, photobiomodulation, splinting, needling, and intra-articular injection. Unfortunately, not any improvements were seen, as either a standalone treatment or as an adjunct, through evaluating self-reported chewing difficulty, mastication-related pain, and bite force/ endurance outcome measures. In addition, considering the discovery of organic lesion/ severe degeneration of joint disks in radiographic examination, surgical reconstruction was thus arranged for all included patients. Each of these patients underwent the same surgical procedure following as below: TMJ interpositional arthroplasty with removal of the damaged disk and debridement of joint and TMF reconstruction. All procedures were performed by a single experienced surgeon (Prof. Gong).

Average follow-up period was 30.07 months after surgery, with a range of 6 to 95 months. Comprehensive radiographic studies were performed preoperatively; and contained wide open and closed mouth cone beam computed tomography (CBCT) as well as the oblique sagittal (wide open and closed mouth), axial (wide open and closed mouth), and coronal (closed mouth) planes of magnetic resonance imaging (MRI) scanning so that the projection angle was in line with Schüller's position [15]. Preoperative and postoperative subjective evaluation was designed performing a visual analogue scale (VAS) scores to evaluate pain (0~10, 0 being "no pain", 10 being "the most pain imaginable") [16]. Preoperative and postoperative objective assessments embraced joint noise on function, deviation on opening, range of movement, and cosmesis.

**Table 1** Included patients population demographics, and baseline data

| Case no. | Gender (F/M) | Age (yr) | Affected side (L/R/Bi) | Previous treatment   | Preoperative radiographic findings <sup>a</sup> |                              | Diagnosis                               | Duration of disease course (mon) |
|----------|--------------|----------|------------------------|--|---|------------------------------|---|----------------------------------|
|          |              |          |                        |  | Disk deformities                                | Bony change                  |   |                                  |
| 1        | F            | 42       | Bi                     | Arthroplasty/proplast  | Folded  | Degeneration                 | OA, disk perforation                    | 24                               |
| 2        | F            | 52       | L                      | Sodium hyaluronate injection   | Biconcave                                       | Degeneration                 | OA                                      | 24                               |
| 3        | F            | 28       | Bi                     | 18 tooth extraction; electrothermal therapy                            | Biplanar  | Condylar head displacement   | OA                                      | 24                               |
| 4        | F            | 59       | R                      | Self-administered prescription of oral antibiotics                     | Biconcave                                       | Abnormal condylar morphology | OA, disk perforation                    | 3                                |
| 5        | F            | 54       | R                      | NM   | Hemiconvexand                                   | Degeneration                 | Nonreducing ADD, synovitis              | 12                               |
| 6        | M            | 60       | L                      | Sodium hyaluronate injection   | Biconvex  | Degeneration                 | Nonreducing ADD, masseter and LPM edema | 4                                |
| 7        | F            | 49       | L                      | NM   | Folded  | Degeneration                 | OA                                      | 20                               |
| 8        | F            | 56       | L                      | Sodium hyaluronate injection   | Folded  | Degeneration                 | OA, disk perforation                    | 24                               |
| 9        | F            | 25       | Bi                     | Sodium hyaluronate injection; stable occlusal splint                   | Biplanar  | Abnormal condylar morphology | OA                                      | 5                                |
| 10       | F            | 28       | R                      | Local anesthesia; stable occlusal splint                               | Folded  | Abnormal condylar morphology | Nonreducing ADD                         | 8                                |
| 11       | F            | 59       | R                      | Required surgical treatment directly                                   | Biconcave                                       | Degeneration                 | OA                                      | 0.5                              |
| 12       | F            | 45       | Bi                     | NM   | Biconvex  | Degeneration                 | Nonreducing ADD                         | 3                                |
| 13       | F            | 30       | Bi                     | NM   | Biconvex  | Degeneration                 | Nonreducing ADD                         | 3                                |
| 14       | F            | 29       | Bi                     | NM   | Folded  | Degeneration                 | OA, disk perforation                    | 11                               |
| 15       | F            | 47       | R                      | Hyaluronic acid injection  |   | Degeneration                 | Nonreducing ADD                         | 18                               |
| 16       | M            | 39       | R                      | Hyaluronic acid injection  | Biconvex  | Degeneration                 | Nonreducing ADD                         | 3                                |
| 17       | F            | 55       | R                      | NM   |   | Degeneration                 | Nonreducing ADD                         | 14                               |
| 18       | M            | 62       | R                      | NM   | Atypical deformation                            | Degeneration                 | OA, disk perforation                    | NA                               |
| 19       | F            | 23       | Bi                     | 48 tooth extraction; hyaluronic acid injection; stable occlusal splint | Folded  | Degeneration                 | OA, disk perforation                    | 48                               |
| 20       | F            | 47       | L                      | NM   |   | Degeneration                 | OA, disk perforation                    | 2                                |
| 21       | F            | 59       | L                      | NM   | Folded  | Degeneration                 | OA, disk perforation                    | 5                                |
| 22       | F            | 67       | R                      | Local anesthesia   | Folded  | Degeneration                 | Nonreducing ADD                         | 11                               |
| 23       | F            | 45       | Bi                     | NM   |   | Degeneration                 | OA, disk perforation                    | 6                                |

**Table 1** (continued)

| Case no. | Gender (F/M) | Age (yr) | Affected side (L/R/Bi) | Previous treatment   | Preoperative radiographic findings <sup>a</sup> |              | Diagnosis            | Duration of disease course (mon) |
|----------|--------------|----------|------------------------|--|---|--------------|----------------------|----------------------------------|
|          |              |          |                        |  | Disk deformities                                | Bony change  |                      |                                  |
| 24       | F            | 53       | L                      | Traditional Chinese medicine therapy including acupuncture, cupping therapy, Tuina manual therapy, and herbal medicine | Biconcave                                       | Degeneration | Nonreducing ADD      | 6                                |
| 25       | F            | 33       | R                      | NM   | Biconvex  | Degeneration | OA, disk perforation | 6                                |
| 26       | F            | 48       | Bi                     | NM   | Biconvex  | Degeneration | Nonreducing ADD      | 12                               |
| 27       | F            | 48       | Bi                     | NM   | Biconvex  | Degeneration | OA, disk perforation | 10                               |
| 28       | F            | 35       | L                      | NM   | Biconvex  | Degeneration | Nonreducing ADD      | 8                                |
| 29       | F            | 55       | R                      | NM   | Hemiconvexand                                   | Degeneration | OA, disk perforation | 24                               |
| 30       | F            | 51       | L                      | Local anesthesia; sodium hyaluronate injection   | Hemiconvexand                                   | Degeneration | OA, disk perforation | 2                                |
| 31       | F            | 30       | R                      | NM   | Biconcave                                       | Degeneration | Nonreducing ADD      | 5                                |
| 32       | F            | 33       | R                      | 18 and 48 tooth extraction; hyaluronic acid injection  | Folded  | Degeneration | OA, disk perforation | NM                               |
| 33       | F            | 29       | R                      | NM   | Biconcave                                       | Degeneration | Nonreducing ADD      | 12                               |
| 34       | M            | 57       | L                      | Hyaluronic acid injection  | Folded  | Degeneration | OA, disk perforation | 1                                |
| 35       | F            | 58       | L                      | NM   | Disk calcification                              | Degeneration | OA, disk perforation | 1                                |
| 36       | F            | 42       | L                      | Oral Meloxicam   | Folded  | Degeneration | OA, disk perforation | 1                                |
| 37       | F            | 26       | L                      | NM   | Folded  | Degeneration | OA, disk perforation | 1.5                              |
| 38       | F            | 52       | Bi                     | NM   | Hemiconvexand                                   | Degeneration | OA, disk perforation | 1                                |
| 39       | F            | 58       | L                      | NM   | Atypical deformation                            | Degeneration | OA, disk perforation | NA                               |

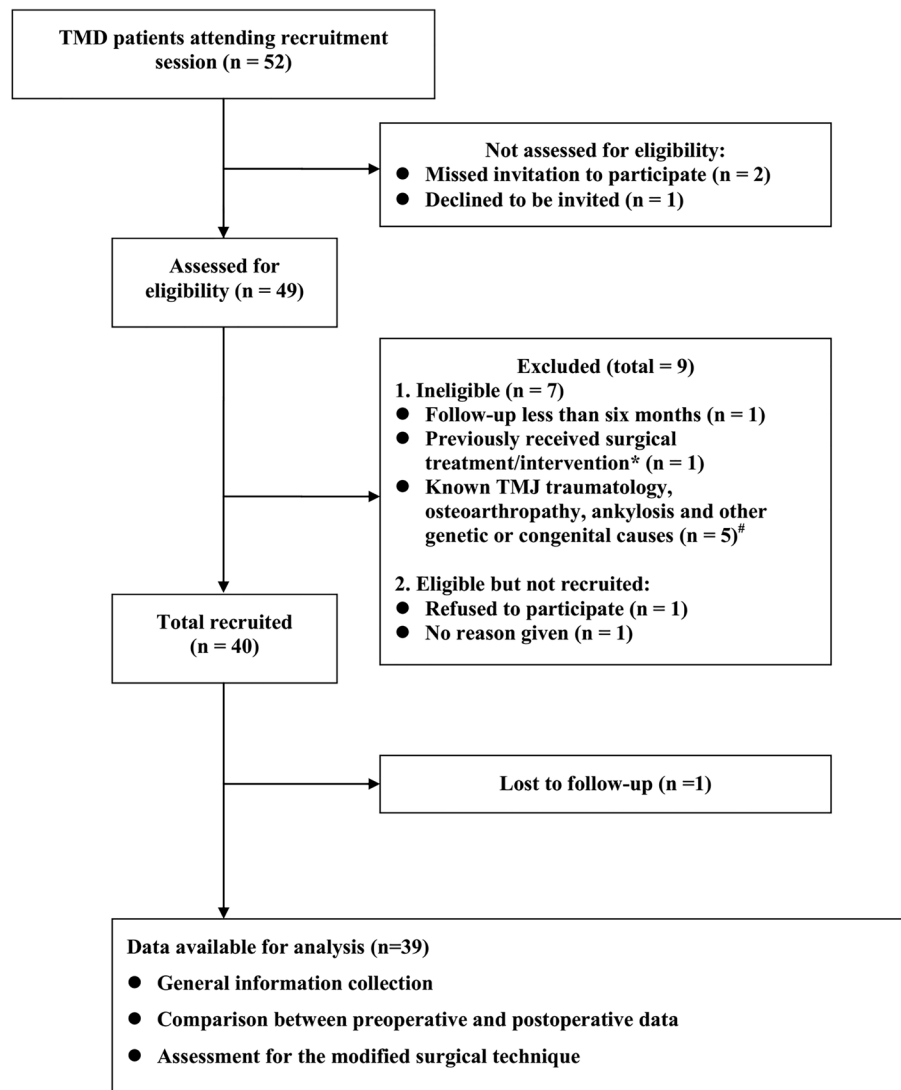
**Abbreviations:** ADD Anterior disk displacement, Bi Bilateral, F Female, M Male, NA Not available, NM Not mentioned, L Left, LPM Lateral pterygoid muscle, OA Osteoarthritis/osteoarthritis, R Right

<sup>a</sup> Radiographic findings were observed through preoperative cone beam computed tomography and magnetic resonance imagings

### Surgical technique

The TMJ was approached through a preauricular incision with a 1.5~2.0 cm extension into the temporal hairline. Local hemostatic solution (with an adrenaline: normal saline ratio of 1 mL: 200 mL) was infiltrated into the skin and underlying tissues to reduce bleeding at the site of surgery. Dissection was conducted via the superficial temporal fascia. The fascia, along with the facial nerve

(mainly temporal branch), were anteriorly retracted; and the periosteum wrapped over the posterior zygomatic arch was incised. Exposure of the condylar eminence and articular fossa of TMJ was accomplished by T-shaped incision of the joint capsule. This approach only incised the superficial fasciculi of lateral ligament to minimize the injury of peripheral soft tissue (Fig. 2). Surgical debridement of the joint, including removal of perforated



**Fig. 1** Study flowchart. \*One patient had an operation history using artificial arthroplastic materials. <sup>#</sup>Two patients suffered with condylar fracture, one suffered with subcortical cyst of condyle, one suffered with joint synovial chondromatosis, one suffered with TMJ ankyloses, respectively. Finally, all enrolled 39 patients were diagnosed as anterior disk displacement without reduction or disk perforation and accepted and underwent the modified minimally invasive surgery in reconstructing the temporomandibular joint disk by transplantation of the pedicled temporalis myofascial flap

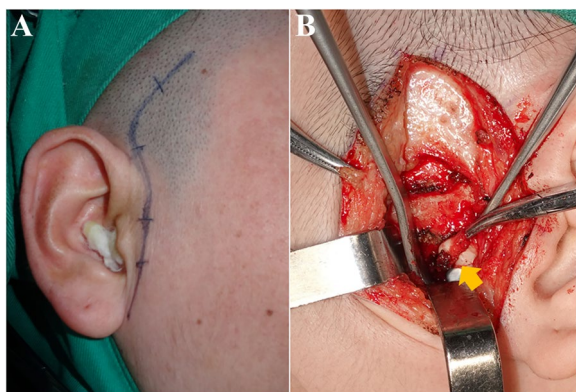
or residual disk and affected soft tissue, was performed. If necessary, the erosive condylar/ articular surfaces were recontoured using a reciprocating rasp.

Once the diskectomy was completed as well as the joint was debrided, the area of pedicled TMF to be proposed was outlined in methylene blue and local hemostatic infiltrated. A posteriorly oriented flap based on the deep temporal vasculature was preferably designed in order to obtain a good orientation relative to the condyle and fossa, when the flap was rotated inferiorly. Within the temporalis muscle proper, there is an intramuscular fascia that divides the more superficial portion of muscle

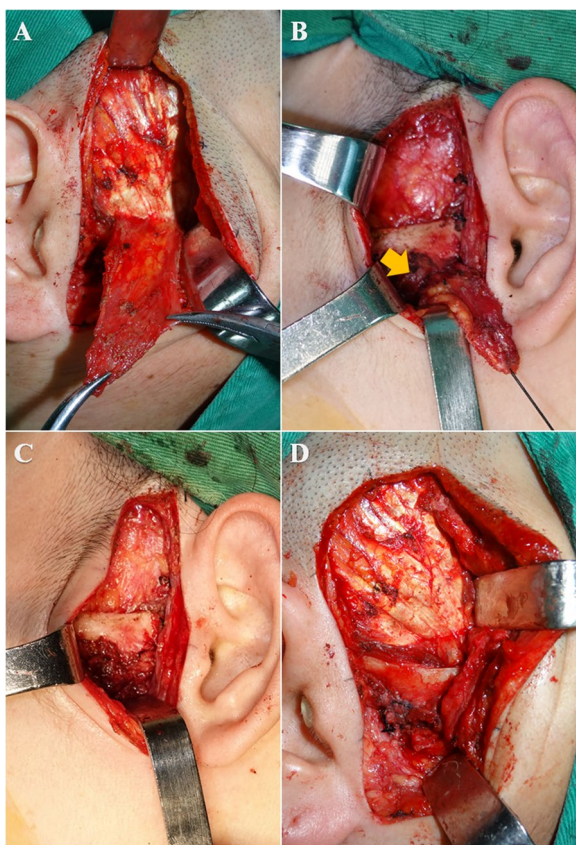
from the deeper portion [17]. The flap was taken from the middle portion of the muscle; and dissection of the outlined flap was carried through to the intramuscular fascia, and a flap consisting of superficial temporalis muscle was created (Fig. 3A).

Unlike conventional way of TMF transference (a zygomatic arch osteotomy described previously in some studies [18–20]), in this surgery, taking the pedicle of TMF as the center, the flap was turned over and through inferiorly deep surface of zygomatic arch and secured in the joint space with nonabsorbable 4–0 PROLENE braided polyester fiber suture (W8557, Ethicon Ltd., USA), so





**Fig. 2** **A** Preauricular skin incision for TMJ arthroplasty with temporalis myofascial flap reconstruction. **B** Disk perforation was presented via T-shaped incision of the joint capsule (indicated by the arrow)



**Fig. 3** Exposure of the joint and donor region was ready for preparation and transference of the temporalis myofascial flap. **A** Pedicled temporalis myofascial flap reflected away from intramuscular fascia. **B** The flap passed through inferiorly deep surface of zygomatic arch, and was inserted into the joint cavity from the deep fasciuli of lateral ligament which was retained. **C** and **D** The interpositional flap covered the top of the condyle and sutured with joint capsule of bilaminar zone

as to allow for atraumatic flap transposition (Fig. 3B-D). Hemostasis might be achieved by electrocautery, and drains were generally not necessary, and pressure dressings were applied.

**Postoperative points for attention**

All patients were required to have a liquid diet within one week, then gradually to have transition to soft diet and general diet. One week after surgery, all patients started their active mouth-opening excises with frequency of 3 to 5 times per day, at least 10 to 15 minutes each time. Additionally, after a week of active motion exercise, all patients initially underwent supervised physical therapy of passive range of motion exercises at least 3 days per week for 3 weeks. Subsequently, they continued daily physical therapy at home for an additional 2 to 3 weeks.

**Statistical analysis**

Statistical analysis was performed using Statistical Analysis System software (version 9.1.3; SAS Institute Inc., Raleigh, North Carolina, USA). The Kolmogorov–Smirnov test as a priori statistical assessment was used to verify the normality of all data. Data conforming to the Gaussian distribution (Sig>0.05) used for paired *t*-test. Otherwise the statistical method applied for non-normally distributed data was Wilcoxon signed-rank sum test, with *P* < 0.05 as significant difference.

**Results**

**Preoperative radiographic evaluation**

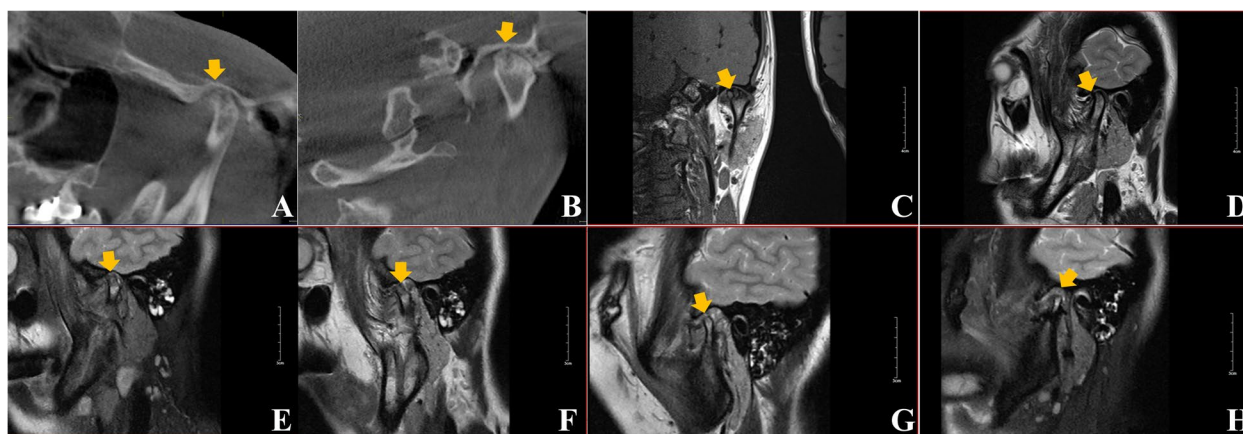
A total of 50 joints were examined; of these assessed joints, 44 showed signs of osseous degeneration, including cortical erosion, condylar flattening, and joint space alterations; 4 joints indicated irregularly abnormal morphology; and 2 joints indicated condylar head displacement (Table 1) (Fig. 4A-D).

**Pre- and post-operative subjective assessment**

Preoperatively, all patients had some degree of pain in the affected joint, ranging from 4.5 to 10 (average score, 8.22 ± 1.94) according to the VAS standard (10 scores being “the most pain imaginable”). Postoperatively, this range was 0 to 9.5, and the mean pain score was 2.21 ± 2.75 (Table 2). The pain score was significantly decreased after reconstructive surgery of disk using TMF transplantation (*P* < 0.001). Fourteen patients rated their pain as “0” postoperatively; five patients complained their pain did not ameliorate after the procedure, but no patient reported an increase in pain evaluation.

**Pre- and post-operative objective assessment**

To assess the range of motion, the maximum mouth opening (MMO) was measured before and after operation



**Fig. 4** Preoperative (A–D) and postoperative (E–H) radiographic results. Fig. A was visualized by oblique sagittal position of cone beam computed tomography (CBCT), B was oblique coronal position of CBCT image; Fig. C was visualized by oblique coronal position of magnetic resonance imaging (MRI), D was oblique sagittal position of MR image. Figs. E, F, G, and H were MRI oblique sagittal slices, with the performance of animate muscle tissue or/and accompanied by adipose tissue indicated by the graft of temporalis myofascial flap in joint space

(Table 3). The average preoperative MMO value was  $29.15 \pm 6.98$  mm (ranging from 12 to 39 mm), and the average postoperative MMO value was  $35.77 \pm 4.47$  mm (ranging from 25 to 42 mm). 32 of 39 patients showed an increase in MMO postoperatively, three patients had no change in MMO, and 4 had an average decrease of 2.25 mm. The mean increase of MMO value after disk reconstruction with the TMF was 7.74 mm. There was a significant increase in MMO postoperatively compared with the preoperative average ( $P < 0.001$ ).

## Discussion

As the only hinge type synovial joint with articular disk, TMJ is featured with intricate structural components to behave in a unique way of bilateral movements namely rotational movement (depression/elevation) and translational movement (lateral deviation and retraction/protrusion). The articular disk is an intrinsic structure of slim and oblong plate that plays crucial role during chewing, as it sustains an enormous amount of pressure to prevent the articular surfaces of bones from coming into contact with each other. For this reason, the disk is a fragile component of the joint especially susceptible to abnormal jaw movement. Patients with serious disk dysfunction or particularly with interpositional TMJ graft failure often pose a challenge for reconstruction and management. These patients frequently have difficulty in maintaining a normal diet resulting from significant pain and limitation of movement.

Autogenous-tissue flap transplantation is still an important method for reconstruction of articular disk after its resection. By reviewing the available literatures, the TMF could be considered as an optimal option compared with

abdominal dermis-fat graft, auricle cartilage, *etc* [21, 22]. TMF is a sort of versatile tool in reconstructing disk, which is possible to use the temporal fascia flap pedicled to the middle temporal vessels, or muscular temporalis flap pedicled to the deep temporal vessels [17, 23]. With regard to TMJ disk replacement, the TMF can meet the physiological function of a disk supplying as autologous tissue. Because this flap is attached to the mandibular condyloid process, it is theoretically pulled forward and down as the condyle translates, therefore simulating the dynamic function of the disk.

Many clinicians have advocated the placement of an interpositional material in the joint after discectomy to avoid crepitus, degenerative changes, pain, ankylosis, occlusional alterations, and limited movement [5, 13, 14]. As a result, the application of TMF in joint surgery was reported by the literature, including TMJ ankylosis, tumour resection, traumatic defect, congenital malformation, joint degeneration, previous failed interpositional TMJ graft procedures, *etc*, as an implant or disk replacement material [19, 24–26]. In this study, a group of thirty-nine cases (fifty sides) was treated with TMF transplantation to reconstruct the articular disk for late disk displacement without reduction, disk perforation, which agreed with the indication of TMF for arthroplasty described in literatures. Our surgical technique utilized the flap that was turned over and through inferiorly deep surface of zygomatic arch and secured in the joint space, by contrast with the traditional method of TMF transference through a zygomatic arch osteotomy [18–20]. Accordingly, this surgical method did not give rise to additional damage to zygomatic arch that simplified the procedure and caused no potential bulging deformity

**Table 2** Preoperative and postoperative pain management

| Case no.          | Affected side (L/R/Bi) | Pain VAS before TMF transplantation | Pain VAS after TMF transplantation | Postoperative pain medications   |
|-------------------|------------------------|-------------------------------------|------------------------------------|--|
| 1                 | Bi                     | 10                                  | 0                                  | None   |
| 2                 | L                      | 10                                  | 2                                  | Narcotic for flare-ups   |
| 3                 | Bi                     | 6                                   | 0                                  | None   |
| 4                 | R                      | 10                                  | 0                                  | Occasional NSAIDs (Paracetamol)  |
| 5                 | R                      | 7                                   | 5                                  | NM   |
| 6                 | L                      | 4.5                                 | 1                                  | Occasional NSAIDs (Paracetamol)  |
| 7                 | L                      | 10                                  | 0                                  | NM   |
| 8                 | L                      | 9                                   | 7                                  | Occasional NSAIDs (Ibuprofen)  |
| 9                 | Bi                     | 10                                  | 3                                  | Occasional NSAIDs (Paracetamol)  |
| 10                | R                      | 7                                   | 0                                  | Occasional NSAIDs (Ibuprofen)  |
| 11                | R                      | 8                                   | 8                                  | Occasional NSAIDs (Ibuprofen);<br>Narcotic for flare-ups                                       |
| 12                | Bi                     | 10                                  | 9.5                                | Narcotic for flare-ups   |
| 13                | Bi                     | 2                                   | 2                                  | Occasional NSAIDs (Ibuprofen)  |
| 14                | Bi                     | 9                                   | 9                                  | Narcotic for flare-ups   |
| 15                | R                      | 10                                  | 6                                  | Occasional NSAIDs (Paracetamol)  |
| 16                | R                      | 10                                  | 2.5                                | Occasional NSAIDs (Ibuprofen);<br>Narcotic for flare-ups                                       |
| 17                | R                      | 10                                  | 1                                  | Ibuprofen; Diclofenac sodium   |
| 18                | R                      | 8                                   | 4                                  | NA   |
| 19                | Bi                     | 5                                   | 5                                  | Occasional NSAIDs (Ibuprofen);<br>Narcotic for flare-ups;<br>Muscle relaxant (Cyclobenzaprine) |
| 20                | L                      | 10                                  | 2.5                                | Occasional NSAIDs (Ibuprofen);<br>Narcotic for flare-ups                                       |
| 21                | L                      | 8                                   | 6.5                                | Narcotic for flare-ups   |
| 22                | R                      | 9                                   | 0                                  | NM   |
| 23                | Bi                     | 8                                   | 2                                  | None   |
| 24                | L                      | 9                                   | 1                                  | None   |
| 25                | R                      | 10                                  | 1                                  | Occasional NSAIDs (Ibuprofen)  |
| 26                | Bi                     | 7                                   | 1                                  | None   |
| 27                | Bi                     | 8                                   | 0                                  | Occasional NSAIDs (Ibuprofen)  |
| 28                | L                      | 8                                   | 0                                  | None   |
| 29                | R                      | 9                                   | 0                                  | Narcotic for flare-ups   |
| 30                | L                      | 7                                   | 2                                  | Narcotic for flare-ups   |
| 31                | R                      | 10                                  | 0                                  | Occasional NSAIDs (Ibuprofen)  |
| 32                | R                      | 10                                  | 0                                  | Occasional NSAIDs (Ibuprofen)  |
| 33                | R                      | 6                                   | 0                                  | None   |
| 34                | L                      | 9                                   | 1                                  | None   |
| 35                | L                      | 8                                   | 2                                  | Occasional NSAIDs (Paracetamol)  |
| 36                | L                      | 5                                   | 1                                  | Occasional NSAIDs (Paracetamol)  |
| 37                | L                      | 10                                  | 0                                  | Occasional NSAIDs (Paracetamol)  |
| 38                | Bi                     | 8                                   | 0                                  | None   |
| 39                | L                      | 6                                   | 1                                  | NA   |
| Average VAS score |                        | 8.22 ± 1.94                         | 2.21 ± 2.75                        | <b>P value*</b><br>< 0.001   |

Abbreviations: Bi Bilateral, NA Not available, NM Not mentioned, L Left, NSAIDs Nonsteroidal anti-inflammatory drugs, R Right, TMF Temporalis myofascial flap, VAS Visual analogue scale

\* $P < 0.05$  was considered as significant



**Table 3** Preoperative and postoperative assessment of function

| Case no.         | Affected side (L/R/Bi) | Initial MIO (mm) | Postsurgical MIO (mm) | P value* |
|------------------|------------------------|------------------|-----------------------|----------|
| 1                | Bi                     | 32               | 34                    | P<0.001  |
| 2                | L                      | 27               | 40                    |          |
| 3                | Bi                     | 12               | 29                    |          |
| 4                | R                      | 20               | 32                    |          |
| 5                | R                      | 23               | 39                    |          |
| 6                | L                      | 18               | 35                    |          |
| 7                | L                      | 13               | 28                    |          |
| 8                | L                      | 30               | 40                    |          |
| 9                | Bi                     | 32               | 34                    |          |
| 10               | R                      | 33               | 38                    |          |
| 11               | R                      | 36               | 35                    |          |
| 12               | Bi                     | 20               | 41                    |          |
| 13               | Bi                     | 30               | 30                    |          |
| 14               | Bi                     | 38               | 34                    |          |
| 15               | R                      | 28               | 31                    |          |
| 16               | R                      | 32               | 35                    |          |
| 17               | R                      | 32               | 35                    |          |
| 18               | R                      | 34               | 35                    |          |
| 19               | Bi                     | 32               | 31                    |          |
| 20               | L                      | 28               | 40                    |          |
| 21               | L                      | 33               | 45                    |          |
| 22               | R                      | 34               | 40                    |          |
| 23               | Bi                     | 39               | 40                    |          |
| 24               | L                      | 35               | 32                    |          |
| 25               | R                      | 18               | 30                    |          |
| 26               | Bi                     | 24               | 40                    |          |
| 27               | Bi                     | 30               | 42                    |          |
| 28               | L                      | 36               | 38                    |          |
| 29               | R                      | 35               | 39                    |          |
| 30               | L                      | 38               | 38                    |          |
| 31               | R                      | 18               | 35                    |          |
| 32               | R                      | 29               | 31                    |          |
| 33               | R                      | 27               | 40                    |          |
| 34               | L                      | 35               | 36                    |          |
| 35               | L                      | 33               | 38                    |          |
| 36               | L                      | 28               | 32                    |          |
| 37               | L                      | 37               | 41                    |          |
| 38               | Bi                     | 25               | 25                    |          |
| 39               | L                      | 33               | 37                    |          |
| Average MMO (mm) |                        | 29.15 ± 6.98     | 35.77 ± 4.47          |          |

Abbreviations: Bi Bilateral, L Left, MIO Maximal interincisal opening, R Right

\*P < 0.05 was considered as significant

of zygomatic arch postoperatively. Another modification regarding the design of operative approach for joint cavity was a T-shaped incision on joint capsule. It would gain a good protection of the normal deep fasciculi of lateral ligament to a great extent, thus better stabilizing the

joint after closure. The patients were followed up for 6 to 95 months, with an average period of 30.07 months after surgery. Postoperative MRI results indicated that the TMF grafts in joint space were animate muscle tissue or/and accompanied by adipose tissue, which showed this

flap was capable to restore joint function and preserve its vitality after transplantation (Fig. 4E-H).

Because our feasibility study contained a relatively small sample size, our findings should be verified by studies involving larger sample sizes. Furthermore, another limitation of the present investigation include the lacking of unilateral and bilateral matching, the potential association between these parameters and different TMJ sides should be clarified. In addition, the sample size of men was smaller than that of women, reflecting the lower prevalence of TMD in men [27]. Studies with sufficient male samples are needed to avoid selective bias and better understand the effectiveness of applied new surgical technique. Randomized controlled trial (modified approach versus conventional approach) is needed to further confirm our findings based on a reliable sample size in the future.

## Conclusion

The temporalis myofascial flap is an autogenous origin that has the advantages of close proximity to the temporomandibular joint, minimal surgical morbidity, and successful clinical results. Attachment to the condyloid process is guaranteed, providing movement of the flap during function, simulating physiologic function of the articular disk. More importantly, these findings offer significant values in TMJ reconstruction with a modified surgical technique that gains atraumatic zygomatic arch as well as keeps extracapsular lateral ligament's deep fasciuli from unnecessary harm in order that best stability can be reached postoperatively. This method is feasible, but its long-term efficacy and related issues need to be further studied.

## Acknowledgements

We would like to express our cordial appreciation to Dr. Ruirui Cui, Amannisahan-Japaer, Yifan Yang, and Ayidana-Wulaerbieke, for their work of data collection; and to our specialized surgical nurse Ms. Jie Yan's experienced assistance in operation. We especially appreciate the support of Prof. Hui Liu (Department of Oral and Maxillofacial Surgery, Shanghai Stomatological Hospital & School of Stomatology, Shanghai Key Laboratory of Craniomaxillofacial Development and Diseases, Fudan University, Shanghai 200003, PR China) for the professional assistance to our work; Dr. Jialin Sun from Department of Preventive Medicine, Faculty of Public Health, School of Medicine, Shihezi University, Shihezi 832003, PR China, in statistical consultation.

## Authors' contributions

Z. Gong conceptualized the study, acquired financial support, and guaranteed the integrity of the whole procedure. C. Li was charge of writing original draft and preparing tables and Figs. P. Yu organized the acquired data and performed the statistical analysis. Z. Gong ran the clinical administration and critically revised the manuscript for important intellectual content. C. Li was responsible for methodology and writing revision and edition. X. Liu supported MRI/CBCT reading and interpreted the images. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work. The requirements for authorship as stated earlier in this document have been met, and that each author believes that the manuscript represents honest work.

## Funding

This study was funded by National Natural Science Foundation of China (grant number: 82160189); Tianshan Innovation Team of Xinjiang Uygur Autonomous Region (grant number: 2021D14001); Open Project of Shaanxi Clinical Medical Research Center for Dental and Maxillofacial Diseases—School of Stomatology, Xi'an Jiaotong University (grant number: 2020YHJB01). Hubei Province Key Laboratory of Oral and Maxillofacial Development and Regeneration, Wuhan 430022, China (grant number: pending).

## Availability of data and materials

The analyzed data sets generated during the study are available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate

The present study was approved by the Ethics Committee of the First Affiliated Hospital of Xinjiang Medical University (approval no. K202211-07). Procedures operated in this research were completed in keeping with the standards set out in the Announcement of Helsinki and laboratory guidelines of research in China. Informed consent was obtained from all subjects/legal guardians.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no conflict of interests.

Received: 2 December 2022 Accepted: 2 January 2023  
Published online: 05 January 2023

## References

- Kreiner M, Vilorio J. A novel artificial neural network for the diagnosis of orofacial pain and temporomandibular disorders. *J Oral Rehabil.* 2022;49(9):884–9. <https://doi.org/10.1111/joor.13350>.
- Boening K, Wieckiewicz M, Paradowska-Stolarz A, Wiland P, Shiau YY. Temporomandibular disorders and oral parafunctions: mechanism, diagnostics, and therapy. *Biomed Res Int.* 2015;2015:354759. <https://doi.org/10.1155/2015/354759>.
- Topaloglu-Ak A, Kurtulmus H, Basa S, Sabuncuoglu O. Can sleeping habits be associated with sleep bruxism, temporomandibular disorders and dental caries among children? *Dent Med Probl.* 2022. <https://doi.org/10.17219/dmp/150615> Epub ahead of print.
- Wieckiewicz M, Smardz J, Martynowicz H, Wojakowska A, Mazur G, Winocur E. Distribution of temporomandibular disorders among sleep bruxers and non-bruxers—a polysomnographic study. *J Oral Rehabil.* 2020;47(7):820–6. <https://doi.org/10.1111/joor.12955>.
- Sidebottom AJ. Open temporomandibular joint surgery: discectomy with or without Interpositional reconstruction? *Atlas Oral Maxillofac Surg Clin North Am.* 2022;30(2):199–204. <https://doi.org/10.1016/j.cxom.2022.05.001>.
- Wieckiewicz M, Grychowska N, Wojciechowski K, Pelc A, Augustyniak M, Sleboda A, et al. Prevalence and correlation between TMD based on RDC/TMD diagnoses, oral parafunctions and psychoemotional stress in Polish university students. *Biomed Res Int.* 2014;2014:472346. <https://doi.org/10.1155/2014/472346>.
- Sandoval-Munoz CP, Haidar ZS. Neuro-muscular dentistry: the "diamond" concept of electro-stimulation potential for stomato-gnathic and oro-dental conditions. *Head Face Med.* 2021;17(1):2. <https://doi.org/10.1186/s13005-021-00257-3>.
- Potier J, Maes JM, Nicot R, Dumousseau T, Cotellet M, Ferri J. Chirurgie discale de l'articulation temporo-mandibulaire [temporomandibular joint disc surgery]. *Rev Stomatol Chir Maxillofac Chir Orale.* 2016;117(4):280–4. <https://doi.org/10.1016/j.revsto.2016.07.014>.
- Dadjoo S, Michelogiannakis D, Rossouw PE, Javed F. Potential adjunct therapies for the management of temporomandibular disorders: an

evidence-based review. *Cranio*. 2022;12:1–11. <https://doi.org/10.1080/08869634.2022.2036437>.

10. Li CX, Liu X, Gong ZC, Liu H, Jumatai S. Effects of condyle on disc status of the reducing and nonreducing anterior disc displacement of the temporomandibular joint based on 3D reconstructive imaging: a pilot study. *Quintessence Int*. 2022;0(0):1–26. <https://doi.org/10.3290/j.qi.b3512027> Epub ahead of print.
11. Li C, Liu X, Muhetaer B, Jumatai S, Gong Z. Magnetic resonance imaging texture analysis of unilateral lateral pterygoid myospasm in patients with temporomandibular joint disorders: a pilot study. *Digit Med*. 2021;7:1–7. [https://doi.org/10.4103/digm.digm\\_31\\_21](https://doi.org/10.4103/digm.digm_31_21).
12. Ottria L, Candotto V, Guzzo F, Gargari M, Barlattani A. Temporomandibular joint and related structures: anatomical and histological aspects. *J Biol Regul Homeost Agents*. 2018;32(2 Suppl. 1):203–7.
13. Bajpai H, Saikrishna D. The versatility of temporalis myofascial flap in maxillo-facial reconstruction: a clinical study. *J Maxillofac Oral Surg*. 2011;10(1):25–31. <https://doi.org/10.1007/s12663-011-0173-5>.
14. Moreau A, Benassarou MA, Benslama L, Goudot P, Schoumann T. Anterior pedicle temporalis muscle flap interposition in the treatment of TMJ disorders. *J Stomatol Oral Maxillofac Surg*. 2018;119(4):325–7. <https://doi.org/10.1016/j.jormas.2018.03.003>.
15. Li CX, Liu X, Gong ZC, Jumatai S, Ling B. Morphologic analysis of condyle among different disc status in the temporomandibular joints by three-dimensional reconstructive imaging: a preliminary study. *BMC Oral Health*. 2022;22(1):395–407. <https://doi.org/10.1186/s12903-022-02438-1>.
16. Espinoza S, Varela D, Richter C, Sepúlveda G, Marfull N. Reproducibility of the Rocabado pain map. *Cranio*. 2020;1:1–7. <https://doi.org/10.1080/08869634.2020.1816038>.
17. Lam D, Carlson ER. The temporalis muscle flap and temporoparietal fascial flap. *Oral Maxillofac Surg Clin North Am*. 2014;26(3):359–69. <https://doi.org/10.1016/j.coms.2014.05.004>.
18. Bergey DA, Braun TW. The posterior zygomatic arch osteotomy to facilitate temporalis flap placement. *J Oral Maxillofac Surg*. 1994;52(4):426–7. [https://doi.org/10.1016/0278-2391\(94\)90455-3](https://doi.org/10.1016/0278-2391(94)90455-3).
19. Smith JA, Sandler NA, Ozaki WH, Braun TW. Subjective and objective assessment of the temporalis myofascial flap in previously operated temporomandibular joints. *J Oral Maxillofac Surg*. 1999;57(9):1058–65. [https://doi.org/10.1016/s0278-2391\(99\)90325-7](https://doi.org/10.1016/s0278-2391(99)90325-7) discussion 1065–1067.
20. Ziccardi VB, Schneider RE, Braun TW. Intramuscular temporalis fascia: a guide to procurement of temporalis myofascial flaps. *J Craniofac Surg*. 1997;8(1):23–8.
21. Dimitroulis G. Macroscopic and histologic analysis of abdominal dermis-fat grafts retrieved from human temporomandibular joints. *J Oral Maxillofac Surg*. 2011;69(9):2329–33. <https://doi.org/10.1016/j.joms.2011.01.048>.
22. Svensson B, Wennerblom K, Adell R. Auricular cartilage grafting in arthroplasty of the temporomandibular joint: a retrospective clinical follow-up. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2010;109(3):e1–7. <https://doi.org/10.1016/j.tripleo.2009.10.029>.
23. Ein L, Daniyan O, Nicolli E. Temporalis muscle flap. *Oper Tech Otolaryngol Head Neck Surg*. 2019;30(2):120–6. <https://doi.org/10.1016/j.otot.2019.04.006>.
24. Desai H, Pande N, Jawdekar A. Comparison of surgical outcomes related to interpositional arthroplasty materials used in patients with temporomandibular joint ankylosis: a systematic review and meta-analysis. *Br J Oral Maxillofac Surg*. 2022;60(8):1023–34. <https://doi.org/10.1016/j.bjoms.2022.05.005>.
25. Qiao J, Yu B, Gui L, Fu X, Yen CK, Niu F, et al. Interpositional arthroplasty by temporalis fascia flap and Galea Aponeurotica combined with distraction Osteogenesis: a modified method in treatment of adult patients with temporomandibular joint Ankylosis and mandibular dysplasia. *J Craniofac Surg*. 2018;29(2):e184–90. <https://doi.org/10.1097/SCS.00000000000004242>.
26. Roychoudhury A, Yadav P, Bhutia O, Kaur K, Dekyi T, Pandey RM. Growth outcome and jaw functions are better after gap arthroplasty plus Costochondral graft reconstruction than gap arthroplasty alone in pediatric temporomandibular joint Ankylosis patients: a cluster randomized controlled trial. *J Oral Maxillofac Surg*. 2021;79(12):2548–61. <https://doi.org/10.1016/j.joms.2021.08.164> Epub 2021 Aug 30. PMID: 34592135.
27. Florjanski W, Malysa A, Orzeszek S, Smardz J, Olchoway A, Paradowska-Stolarz A, et al. Evaluation of biofeedback usefulness in masticatory muscle

activity management—a systematic review. *J Clin Med*. 2019;8(6):766. <https://doi.org/10.3390/jcm8060766>.

## Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Ready to submit your research? Choose BMC and benefit from:**

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

**At BMC, research is always in progress.**

Learn more [biomedcentral.com/submissions](https://biomedcentral.com/submissions)

