Case Series

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Magnetic resonance imaging-guided disc–condyle relationship adjustment via articulation: a technical note and case series

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Abstract

A normal disc–condyle relationship is crucial to the health and function of the temporomandibular joint. We herein introduce a novel technique that can precisely and rapidly restore the disc–condyle relationship. An initial bite rim was made, and the patient was instructed to wear this bite rim during magnetic resonance imaging (MRI) scanning. A quick MRI scan was performed, and the disc–condyle relationship and direction and vector of the displacement was measured. Adjustments to the mandible position were made on an articulator based on the measurements, after which a second bite rim was made. A second quick preview MRI scan was immediately performed, and the images were evaluated and measured again. Additional adjustments were made as needed, and the preview scan was repeated until an ideal disc–condyle relationship was achieved. Once a good disc–condyle relationship was acquired, the mandible position was recorded as the treatment mandible position, and a splint was fabricated. MRI visualization enabled precise and very fine adjustment of the disc–condyle relationship by articulating. This technique might help to simplify the clinical process and improve treatment effectiveness.

Keywords

Magnetic resonance imaging, temporomandibular joint, disc displacement, articulator, mandible position, bite rim

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Introduction

In a normal temporomandibular joint (TMJ), the articular disc is interposed between the condyle and the articular eminence, either closed or open.[1] An abnormally placed disc, including anterior, lateral, or medial displacement,[2] might contribute to subsequent disc deformities or osseous changes of the condyle as time processes,[3–5] leading to a decreased quality of life.[6] Management of an abnormal disc–condyle relationship is therefore beneficial to restoring a normal joint structure and maintaining good health. Both conservative and surgical approaches have been used to restore a good disc–condyle relationship, but the outcomes have not been satisfactory.

Mandibular manipulation (MM) aims to recapture the anteriorly displaced disc by enforced distraction of the condyle downward and forward.[7] However, the prognosis of MM varies, and <25% of cases are reportedly successful.[8] An anterior repositioning splint (ARS) is a removable full-coverage appliance with a bite block that rests lingual to the lower anterior teeth. An ARS can guide or force the mandible to a protruded position beyond the disc clicking point, therefore fetching the disc by the anteriorly positioned condyle. This splint provides good stability and maintains the mandible position. One study in which an ARS was used to treat disc displacement with reduction (DDwR) revealed a high 1-year success rate of 92.3% (84 of 91 patients).[9] However, after removing the ARS in another year of follow-up, the recurrence rate was considerable at 21.4% (18 of the 84 patients who had achieved a successful outcome).[9] A combined treatment for acute disc displacement without reduction (DDw/oR) using arthrocentesis, MM, and an ARS showed a promising 1-week success rate of 95.2% (20 of 21 patients)[10]; however, its long-term effect requires further validation. The effect of conservative treatment appears to be unclear because of low sensitivity of the currently available techniques and ambiguity of the results.[9] Surgery can effectively restore the disc–condyle relationship.[1] Because of its invasive nature, however, surgery is usually considered when conservative therapies are ineffective.

Magnetic resonance imaging (MRI) is widely used to evaluate the characteristics of the TMJ, especially the disc–condyle relationship. Early evaluation of patients with TMJ symptoms helps in rapid selection of the most appropriate treatment strategies.[11] We herein describe a technique in which MRI scanning was combined with a pre-splint bite transferring technique using an articulator. This allowed for precise and rapid kinematic evaluation and subsequent determination of the treatment position of the mandible.

Case series

This study protocol was approved by the institutional review board of our hospital (Approval no. WCHSIRB-D-2019-049) and carried out at the TMJ department. All patients seeking treatment were informed of the possibility that their records might be used for teaching and research purposes, and informed consent was obtained.

Transferring the bite

The patient's diagnostic casts were mounted on a fully adjustable articulator (Artex® CR; Amann Girrbach, Koblach, Austria). The reference plane was recorded and marked so that it coincided with the subsequent measurement based on the MRI scan. The mandible position was registered using the modified reference position (MRP) method.[12]

Initial bite rim for MRI preview scan

An initial (MRP) bite rim was made using bite registration silicon (granit PERFECT;

Müller-Omicron GmbH & Co. KG, Lindlar, Germany) and delivered. The patient was instructed to wear this MRP bite rim during the MRI scan. T_2-weighted imaging was performed with a fast spin echo sequence in the oblique sagittal plane (MRP) and coronal plane using a 1.5-T MRI scanner (Signa; GE Healthcare, Milwaukee, WI, USA) with TMJ surface coils. The detailed MRI parameters were as follows: repetition time (TR), 2300 ms; echo time (TE), 45 ms; slice thickness, 3 mm; number of averages, 2; field of view, 14 × 14; and matrix, 288 × 256.

MRI-guided disc–condyle relationship adjustment

A quick (approximately 3-minute) MRI preview scan of the TMJ was performed in the closed-mouth position, and the preview images were used for the subsequent measurement and calculation. The disc–condyle relationship was evaluated and the direction and vector of the displacement were measured based on the recorded reference plane (Figure 1).

The fully adjustable articulator allows three-dimensional adjustments of the mandible. Adjustments to the mandible position were made on the articulator based on the measurements, and the alterations were recorded. A second bite rim was then made. A second quick preview MRI scan was immediately performed, and the images were evaluated and measured again. Additional adjustments were made as needed, and the preview scan was repeated until an ideal disc–condyle relationship was achieved.

Dynamic MRI scan and kinematic evaluation

Once a good disc–condyle relationship was acquired, a comprehensive dynamic MRI scan was performed during opening and closing movements of the mandible. This scan was performed using a fast imaging employing steady-state acquisition (FIESTA) sequence with the following parameters:

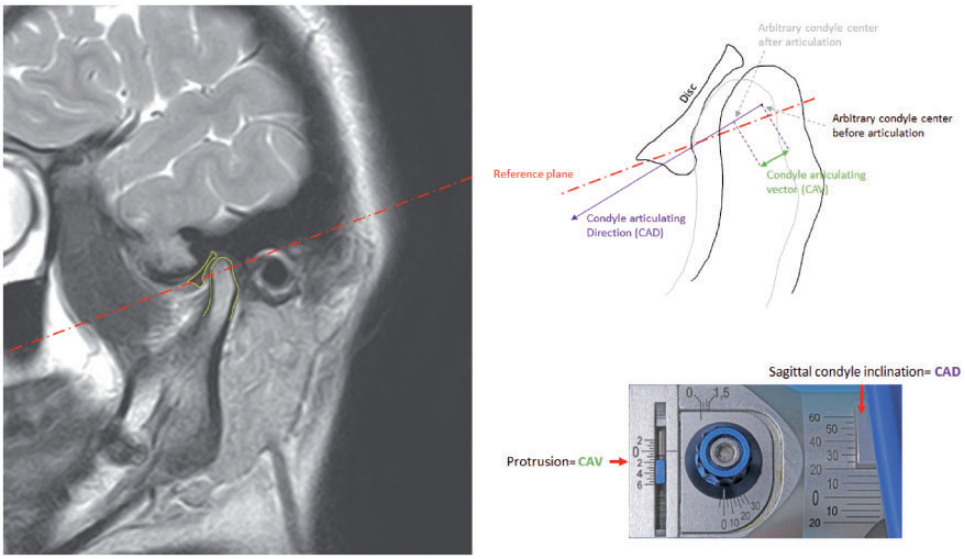

Figure 1. Measurements were based on the magnetic resonance image (oblique sagittal plane), and adjustments on the articulator were made accordingly. The lateral adjustment was made by a similar method using the coronal plane image.

TR, 7.4 ms; TE, 3.4 ms; slice thickness, 5 mm; number of averages, 1; field of view, 10×10; and matrix, 192×128. Compared with the first MRI procedure, the final procedure aimed to re-evaluate the disc–condyle relationship in detail in either the closed- or open-mouth position, as well as during movements, to ensure adequacy of the disc–condyle relationship and normal function of the joints. If the acquired disc–condyle relationship was qualified, the mandible position was recorded as the treatment mandible position (TMP), and a splint was fabricated; otherwise, minor adjustments were made on the articulator, and the above-described adjustment protocol was repeated until the disc–condyle relationship was qualified.

Results

Twenty patients were treated with this technique (3 male, 17 female). The age of the 20 patients ranged from 17 to 59 years (mean, 31.35 ± 14.32 years). Among the 40 TMJs, 2 joints had a normal disc–condyle relationship, 26 had DDwR, and 12 had DDw/oR. The mean adjustment values for the left TMJ were $33.5° \pm 8.17°$ of sagittal condyle inclination (SCI), 0.90 ± 0.68 mm of protrusion, and 0.23 ± 0.44 mm of distraction, and those for the right TMJ were $36.7° \pm 6.59°$ of SCI, 1.00 ± 0.54 mm of protrusion, and 0.13 ± 0.22 mm of distraction. Sixteen patients underwent one adjustment, three patients underwent two adjustments, and one patient underwent three adjustments. The average number of adjustments was 1.25. For TMJs with DDwR, the successful recapture rate was 84.62% (22/26); however, none of the TMJs with DDw/oR returned to normal (Table 1).

Image example

A male patient with bilateral DDwR reported a 1-month history of clicking in the bilateral TMJs. His diagnostic casts were mounted on the articulator at the MRP. The patient underwent the first preview MRI scan wearing the MRP bite rim (Figure 2). The preview images showed that the bilateral discs were displaced by 1 mm in the 35° direction. Thus, we set the bilateral SCI of the articulator at 35° and created a 1-mm protrusion of the bilateral condylar part (Figure 3). A second bite registration was made, and the patient underwent another preview scan. The images from the second scan showed an improved condyle–disc relationship (Figure 4), and the patient's bilateral joint clicking had disappeared. The dynamic scan showed smooth, synchronous movement of the condyle and disc (Supplemental data 1). The adjustments were recorded for the final TMP. A full-coverage splint with stable intercuspation to the opposing dentition was fabricated based on this treatment position, allowing repositioning of the mandible and anterior and lateral guidance of mandibular movement. After the splint was delivered, the clicking in both joints was relieved. The post-treatment MRI showed that the disc–condyle relationship was restored, and the mandible position was well maintained with a computer-aided design/computer-aided manufacturing (CAD/CAM) splint (Figure 5) during long-term observation.

Discussion

The herein-described technique is a noninvasive and fully reversible approach that can be used to more precisely and rapidly restore the disc–condyle relationship compared with the traditional time-consuming splint therapy, which renders an unstable effect.[13] A good disc–condyle relationship can usually be restored after only one or two adjustments. During the whole articulating process, the patient is instructed to avoid changing his or her head position while undergoing the preview scans (once or twice), which take <10 minutes to complete.

Table 1. Patient information and records of adjustments.

Patient no.	Sex	Age (years)	Disc–condyle relationship		Values of adjustments						Number of adjustments	Successful recapture	
			Left	Right	Left SCI	Protrusion	Distraction	Right SCI	Protrusion	Distraction		Left	Right
1	F	18	DDw/oR	DDw/oR	40°	1 mm	0 mm	42°	1 mm	0 mm	1	No	No
2	F	26	DDwR	DDwR	38°	2.5 mm	1 mm	42°	1 mm	0 mm	3	Yes	Yes
3	F	18	DDwR	DDwR	37°	1 mm	0 mm	37°	1.5 mm	0 mm	1	Yes	Yes
4	F	61	DDwR	DDwR	28°	0.5 mm	0 mm	28°	0.5 mm	0 mm	1	Yes	Yes
5	F	27	DDwR	DDwR	20°	1 mm	0 mm	30°	1.5 mm	0 mm	1	Yes	Yes
6	F	27	DDw/oR	DDwR	30°	0 mm	1 mm	40°	0.5 mm	0 mm	2	No	Yes
7	F	18	Normal	DDwR	28°	1.5 mm	0 mm	32°	1.5 mm	0 mm	1	–	Yes
8	M	37	DDwR	DDwR	35°	1 mm	0 mm	35°	1 mm	0 mm	1	Yes	Yes
9	F	27	DDwR	DDwR	20°	1.5 mm	0.5 mm	28°	1.5 mm	0.5 mm	1	No	No
10	F	22	DDwR	DDw/oR	32°	0.5 mm	0 mm	30°	1 mm	0.5 mm	1	Yes	No
11	F	21	DDwR	DDw/oR	40°	1 mm	0 mm	38°	1.5 mm	0 mm	1	Yes	Yes
12	F	30	Normal	DDwR	40°	0 mm	0 mm	38°	0.5 mm	0 mm	1	–	Yes
13	F	42	DDwR	DDwR	36°	1.5 mm	0 mm	40°	1 mm	0 mm	2	Yes	Yes
14	F	40	DDw/oR	DDw/oR	35°	2 mm	0 mm	34°	2 mm	0.5 mm	1	No	No
15	F	17	DDwR	DDw/oR	24°	0.5 mm	0 mm	30°	1 mm	0 mm	1	Yes	No
16	M	59	DDwR	DDwR	57°	0.5 mm	0 mm	56°	0 mm	0.5 mm	1	Yes	Yes
17	F	54	DDw/oR	DDwR	33°	0 mm	1.5 mm	40°	1.5 mm	0 mm	1	No	Yes
18	F	45	DDwR	DDw/oR	35°	1 mm	0 mm	43°	1 mm	0 mm	1	No	No
19	F	17	DDwR	DDw/oR	30°	0 mm	0 mm	35°	0 mm	0.5 mm	1	Yes	No
20	M	21	DDw/oR	DDwR	32°	1 mm	0.5 mm	36°	0.5 mm	0 mm	2	No	No

F, female; M, male; DDwR, disc displacement with reduction; DDw/oR, disc displacement without reduction; SCI, sagittal condyle inclination.

Figure 2. The patient was instructed to wear the bite rim while undergoing the quick magnetic resonance imaging preview scan.

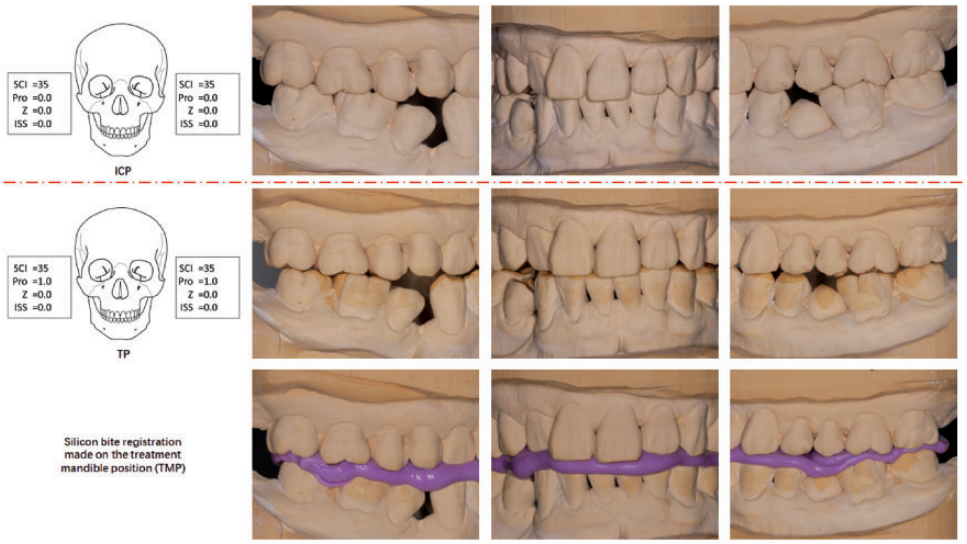

Figure 3. The articulation was made and recorded according to the measurements, and the silicone bite rim was made in the treatment mandible position.

The overall procedure takes around 30 minutes. Instead of surgery, this treatment can be chosen as the first step.

The quick preview scan allows clear visualization of the position of the condyle and displaced disc, thus enabling precise and very fine adjustment by articulating. Compared with the use of an ARS or MM, the ability to visualize the positions makes this treatment process more controllable and less skill-sensitive. After the disc is fetched, another dynamic MRI scan is immediately performed to check the joint function during movement; the disc–condyle relationship is

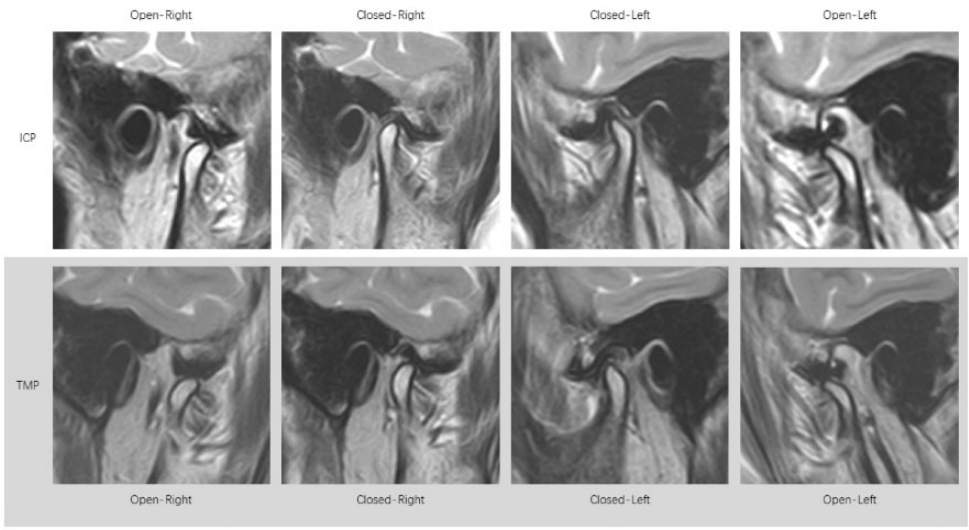

Figure 4. The second magnetic resonance imaging scan showed an improved disc–condyle relationship in the treatment mandible position compared with the intercuspation position.

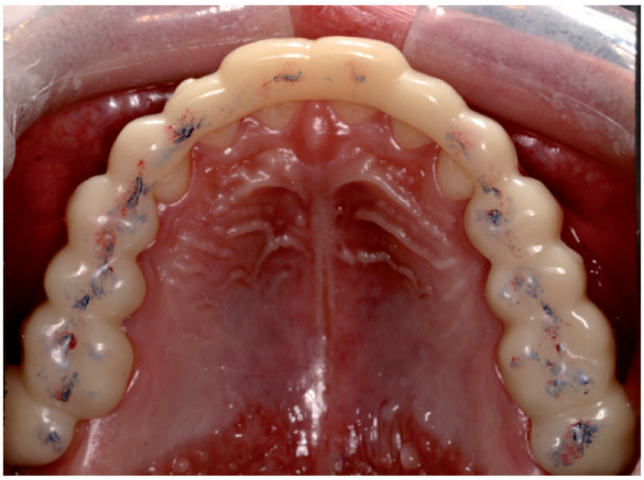

Figure 5. A computer-aided design/computer-aided manufacturing splint was designed and fabricated using this magnetic resonance imaging-guided articulating method.

thus evaluated in real time. Using this immediate check and readjust process, the TMP is proven by its effect, which secures the subsequent splint validity. The diagnostic nature of this technique can be used as a tool to predict the prognosis of an abnormal disc–condyle relationship.

Skill details

Transferring the upper jaw to the articulator is critical, and an arbitrary hinge axis is not used. Instead, the real position of the condyles is used to build the reference plane, therefore making the condylar parts

on the articulator accurately correspond to the condyles and allowing for subsequent adjustments. When using this technique, every adjustment should be recorded in detail because these measurements will be used as a reference for the subsequent articulating steps or for splint CAD/CAM. By doing so, the displaced disc with solid structure and good elasticity can be fetched and secured with the splint.

Limitations

Degenerated discs cannot be restored using this technique. In our study, all discs in patients with DDw/oR were deformed; thus, none of them were successfully recaptured. Additionally, this technique requires additional MRI scans of the patients, which might increase the patients' financial burden depending on the charge standards of different facilities. However, if an ideal disc–condyle relationship is restored using this technique, the other subsequent treatments, including invasive methods such as surgeries, would not be necessary.

In conclusion, we have presented a clinical approach in which making adjustments to the disc–condyle relationship is visible and controllable under MRI surveillance. This technique allows precise control of the disc–condyle relationship and might help to simplify the clinical process and improve treatment effectiveness.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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Supplemental material

Supplemental material for this article is available online.

References

1. Okeson JP. *Management of temporomandibular disorders and occlusion*. 8th ed. St. Louis: Mosby, 2019, p.512.
2. Vogl TJ, Lauer HC, Lehnert T, et al. The value of MRI in patients with temporomandibular joint dysfunction: Correlation of MRI and clinical findings. *Eur J Radiol* 2016; 85: 714–719. DOI: https://doi.org/10.1016/j.ejrad.2016.02.001.
3. Wilkes CH. Internal derangements of the temporomandibular joint: pathological variations. *Arch Otolaryngol Head Neck Surg* 1989; 115: 469–477.
4. Lei J, Han J, Liu M, et al. Degenerative temporomandibular joint changes associated with recent-onset disc displacement without reduction in adolescents and young adults. *J Craniomaxillofac Surg* 2017; 45: 408–413. DOI: https://doi.org/10.1016/j.jcms.2016.12.017.
5. Lei J, Yap AUJ, Liu M, et al. Condylar repair and regeneration in adolescents/young adults with early-stage degenerative temporomandibular joint disease: A randomised controlled study. *J Oral Rehabil* 2019; 46: 704–714.
6. Kurita H, Kojima Y, Nakatsuka A, et al. Relationship between temporomandibular joint (TMJ)-related pain and morphological changes of the TMJ condyle in patients with temporomandibular disorders. *Dentomaxillofac Radiol* 2004; 33: 329–333. DOI: 10.1259/dmfr/13269559.
7. Chiba M and Echigo S. Longitudinal MRI follow-up of temporomandibular joint internal derangement with closed lock after successful disk reduction with mandibular manipulation. *Dentomaxillofac Radiol* 2005; 34: 106–111.
8. Mehmet Muhtaroğulları M, Atila Ertan A, Demiralp B, et al. Correlation between clinical and magnetic resonance imaging findings in the treatment of anterior disc displacement. *Int J Prosthodont* 2013; 26: 138–142.

9. Ma Z, Xie Q, Yang C, et al. Can anterior repositioning splint effectively treat temporomandibular joint disc displacement? *Sci Rep* 2019; 9: 534.
10. Lei J, Yap AU, Li Y, et al. Clinical protocol for managing acute disc displacement without reduction: a magnetic resonance imaging evaluation. *Int J Oral Maxillofac Surg* 2020; 49: 361–368. DOI: 10.1016/j.ijom.2019.07.005.
11. Matsubara R, Yanagi Y, Oki K, et al. Assessment of MRI findings and clinical symptoms in patients with temporomandibular joint disorders. *Dentomaxillofac Radiol* 2018; 47: 20170412. DOI: 10.1259/dmfr.20170412.
12. Zhongjie L, Tingting L and Yang L. Arguing over the definitions and its implication: Reconsidering centric relation in dentistry. *Ann Dent Oral Health* 2018; 1: 1005. DOI: 10.33582/2639-9210/1005.
13. Shen P, Chen X, Xie Q, et al. Assessment of occlusal appliance for the reposition of temporomandibular joint anterior disc displacement with reduction. *J Craniofac Surg* 2019; 30: 1140–1143.