Prognostic Indicators of Yang's Arthroscopic Technique for Management of Temporomandibular Joint Anterior Disc Displacement: Part 1- Clinical Predictors.

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Research Article

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Abstract

In order to optimize the patient selection for specific treatment modality and to achieve favorable treatment outcomes, prognostic indicators impacting the results are important to analyze. This longitudinal retrospective study aimed to analyze various prognostic factors impacting the surgical outcomes following Yang's arthroscopic discopexy for management of temporomandibular joint anterior disc displacement using success criteria based on pain, maximal interincisal opening, diet, and quality of life. Furthermore, a quantitative MRI assessment of disc position and condylar height was performed pre- and postoperatively. Multinomial analysis was used to evaluate various prognostic variables including gender, age, duration of illness, Wilkes staging, parafunctional habits, and splint/orthodontic therapy. A total of 169 patients (234 joints) were included. The outcome was categorized as excellent (n = 67/39.6%), good (n = 72/42.6%), improved (n = 22/13.01%) or poor (n = 8/4.73%) with a success rate of 95.26%. Patients aged from 11–15 years old were significantly more likely to be in the good outcome group (odds ratio (OR), 0.20; $P < 0.05$). Also, patients with shorter duration of illness (OR, 0.29; $P < 0.05$) and with Wilkes stage III (OR, 0.11; $P < 0.05$) were more likely to be in the improved outcome group. Better outcomes can be achieved at younger patients with shorter disease history and earlier Wilkes staging.

Introduction

Anterior disc displacement (ADD) of the temporomandibular joint (TMJ) is so far the most frequently encountered form of TMJ internal derangement (ID) with an estimated incidence rate of 36% of the general population, of which 81.25% was found to be pure ADD, more prevailing in females at their twenties[1]. The clinical scenario of ADD commonly consists of pain, joint sounds, limitation of mouth opening, and might be associated with osteoarthritic changes at late disease stages[2,3]. Most patients get benefit of the conservative treatments that include medical therapies, physiotherapy and occlusal splints, etc. However, still a considerable proportion of patients with a predominance of degenerative findings is refractory for such regimen after a period of non-interventional treatment, for whom, surgical procedures are being advocated including disc repositioning techniques[4,5].

Among various surgical interventions for management of ADD, the arthroscopic disc suturing and repositioning technique is now gaining more popularity due to development of new technologies and refinement of the provisional methods[6–8]. Since the original reports of arthroscopic disc suturing[9–11], such technique has passed through different approaches with various rates of success and outcomes. Then, McCain et al.[12] reported an eminent technique of arthroscopic disc repositioning and suturing, with a success rate of 81.8%, however with smaller sample size (11 joints). Later, Yang et al.[13] introduced a new technique of arthroscopic TMJ disc repositioning and suturing, applied on 2167 subjects (2622 joints), with a higher success rate (98.07%), demonstrated in the short- and long-term follow ups evidenced in magnetic resonance imaging (MRI)[14].

The postoperative outcomes of TMJ arthroscopy have been analyzed in previous literature reports either based on individual clinical factors[15,16] or combined clinical and MRI data[17]. However, they all lack the followings: 1) most reports analyzed a single variable, and seldom reports combined variable effects; 2) all previous articles analyzed the outcomes of arthroscopic lysis and lavage with paucity of reports investigating the arthroscopic disc repositioning procedure correlated with different variables.

Notwithstanding the higher success rate reported with Yang's arthroscopic technique[13,14], still some cases have been reported with unfavorable outcomes at different follow up intervals. Therefore, the authors suppose that a multinomial regression analysis of different variables impacting the outcomes, would be critical in terms of prognosis and better patient selection. The current study aimed to retrospectively analyze different prognostic factors including gender, age, duration of illness, Wilkes staging, parafunctional habits, and splint/orthodontic therapy to correlate with the clinical and radiological outcomes of TMJ arthroscopic disc repositioning in a multinomial regression analysis model.

Materials And Methods

Study design. The current research retrospectively included all consecutive patients diagnosed as anterior disc displacement (ADD) and were operated with Yang's arthroscopic disc repositioning and suturing technique from March, 2014 to September, 2016 in the Department of Oral Surgery, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University, School of Medicine. This study was accomplished in accordance with the principles outlined in the Declaration of Helsinki, with an approval of the Ethics Committee of Shanghai Ninth People's Hospital. An informed written agreement was obtained from all participants.

All arthroscopic procedures were performed by one senior surgeon (Chi Yang), with more than 40 years' experience.

Inclusion criteria:

1. Patients having at least one recent preoperative MRI (within 3 months),
2. Having a minimum of two postoperative MRI scans (at least 6 months apart),
3. Patients presenting with stages II-V (Wilkes classification)[18],
4. Patients operated with Yang's TMJ arthroscopic disc suturing and repositioning technique,
5. Adequate pre and postoperative clinical data.

Exclusion criteria:

Patients were excluded as study subjects if:

1. Patients with septic arthritis or synovial chondromatosis,

2. Psychological disorders,
3. Joints operated before for any other TMJ problems,
4. Insufficient or unclear MRI data,
5. Missing clinical data or follow ups of patients.

Study variables

The primary predictor variables. Different prognostic variables including gender, age, duration of illness, Wilkes staging, parafunctional habits, and splint/orthodontic therapy.

The primary outcome variables. Clinical outcomes [maximal interincisal opening (MIO), pain, diet, and quality of life (QOL)].

The secondary outcome variables. MRI-based radiological outcomes (disc position and condylar height).

Arthroscopic procedure[13]. Local anesthesia was applied in all arthroscopic surgeries that consisted mainly of four portals of entry. Following fossa portal entry, the arthroscope was introduced into the posterior recess, followed by thorough examination of the joint cavity to confirm the diagnosis of ADD. Under a complete arthroscopic visualization, the eminence portal was achieved, through which the coblation probe accessed the anterior recess for anterior release. Through a midway access point between the first two punctures, a 12-gauge needle was introduced into the upper joint space to penetrate the TMJ disc 1-2 mm ahead of the junction between the body of the cartilaginous disc and posterior retrodiscal tissue. A third transmeatal puncture was made, through which the custom-made suture needles were inserted. A specially-manufactured non-absorbable surgical suture material was passed from the 12-gauge needle and pulled out via the transmeatal portal with the help of the lasso- and hook-type grippers. Similarly, a second suture was made for better securing the disc position. A stabilizing splint was used for all patients after surgery.

Evaluation and workflow analysis of prognostic variables (Figure 1). All patients' records including gender, age, duration of illness, Wilkes staging, parafunctional habits, and splint therapy, were reviewed and analyzed. Also, MRI data were reviewed for disc position and condylar height.

All preoperative patient data were input into a multinomial regression analysis to calculate a prognostic model for success or failure following the arthroscopic disc repositioning operations. The outcome items included:

1. Maximal interincisal opening (MIO), (success ≥35mm),
2. Pain scores measured with visual analogue scale (VAS), (success ≤3),
3. Diet scores (success ≤3),
4. Quality of life (QOL) (4 was indicative of success).

The outcomes of arthroscopic disc repositioning and suturing were categorized into four different subgroups namely, excellent, good, improved, and poor based on the analyzed postoperative data for more than two years.

An excellent outcome was confirmed when all 4 clinical parameters were fulfilled (MIO≥35, pain≤3, diet≤3, and QOL=4). A good result was defined if any of the 4 clinical parameters was missing, while if two or three items were not fulfilled, then an improved outcome was the scene. A poor outcome was defined when all the above parameters were not fulfilled.

Clinical follow-up assessment[8]. MIO was measured using a conventional ruler preoperatively and at 3, 6, 12, 24 months postoperatively. Pain was evaluated using a 10-cm VAS scale (where '0' means no pain and '10' representing the worst pain) preoperatively and at all postoperative follow-up intervals. The median VAS score at the final postoperative visit was compared with the preoperative VAS score. Diet was also evaluated using VAS from 1 (regular diet) to 10 (only fluids) and QOL assessmnt was done using a four point VAS scale from 1 (rest in bed) to 4 (ordinary daily activities) at pre- and postoperative visits.

MRI Acquisition and evaluation. MRI scans were obtained from a 1.5-Tesla imager (Signa, General Electric, Milwaukee, WI) with 3-inch TMJ surface coil receivers on bilateral sides. The parasagittal eight sections of T1-weighted spin-echo sequence scan from lateral to medial for each TMJ in the closed mouth position were first examined using a computer dataset (Y410P, Lenovo Computer, Beijing, China). The central image displaying the largest sectional area (usually the fourth or fifth slice) of the condyle was selected for tracing the reference planes and drawing the layouts of the joint structures by utilizing Adobe Photoshop CS5 (Adobe Systems, San Jose, CA). Besides, the linear measurements for condylar height and disc position were estimated by utilization of MB-Ruler estimating programming (Markus Bader, Berlin, Germany, precise to 0.01 mm). The construction of the tangent line at the posterior border of the ramus to assess condylar height was determined based on the method described by Markic et al.[19] while the disc displacement distance was determined according to the method of Xie et al.[20].

Assessment of condylar height. For every MRI image, three points, condylion (p), disc point (q), and incisura (G) were defined, and two linear measurements were drawn perpendicular to the tangent at the posterior border of the ramus. A tangent line (AB) was drawn at the posterior border of the ramus passing through two points, first: the most cranial and convex bulge on the back of the condyle, second: the most caudal and convex bulge on the back of the ramus. From line AB, two perpendicular lines CD and EF were drawn passing through the deepest point of the sigmoid notch (G) and the top point of the condylar head (p). The distance between lines CD and EF was defined as condylar height (Figure 2 & 3).

Measurement of disc position. Another point (point q) at the posterior most convex point of the disc was identified. A straight line drawn from point p to point q was represented as disc displacement/reposition distance relative to the condyle (Figure 2 & 3).

Statistical analysis. Data were analyzed statistically using SPSS software package version 25.0 (Armonk, NY: IBM Corp). A multinomial logistic regression was used to investigate the correlation between patient-specific factors (prognostic variables) and the surgical outcomes with the excellent outcome being set as a reference. All preoperative variables with a significant impact on the surgical outcomes were used in an adjusted regression model to address the possible confounders. Furthermore, Wilcoxon signed ranked test was conducted to analyze the association of disc position and condylar height differences as well as to evaluate the clinical outcomes pre- and post-operatively. Probabilities (*p*-value) of less than 0.05 were considered significant.

Results

Description of patients. A total of 169 patients were enrolled in the final analysis, including 151 females (89.35%) and 18 males (10.65%) with a mean age of 20.23 ± 7.04 years. The right joint was involved in 49 patients (28.9 %), the left joint in 55 patients (32.5 %), and bilateral joints were affected in 65 patients (38.4 %), with a total of 234 joints. The mean value of follow up period was 25.12 ± 8.8 months (range: 9 to 58 months). There were 67 patients (39.64%) in the excellent group, 72 patients (42.60%) in the good outcome group, and 22 patients (13.01%) in the improved group with a total success rate of 95.26%, while poor outcome was found in 8 patients (4.74%). All demographic and basic data of the included subjects are summarized in Table 1.

Table 1
Demographics and clinicopathologic characteristics of patients based on their surgical outcomes.

Variables	Outcome categories			
	Poor (n = 8)	Improved (n = 22)	Good (n = 72)	Excellent (n = 67)
Gender				
Female	8(100.0%)	22(100.0%)	63(87.5%)	58(86.6%)
Male	0	0	9(12.5%)	9(13.4%)
Age group				
11–15 years	1(12.5%)	3(13.6%)	12(16.7%)	23(34.3%)
16–20 years	4(50.0%)	8(36.4%)	33(45.8%)	26(38.8%)
21–25 years	2(25.0%)	9(40.9%)	11(15.3%)	11(16.4%)
> 25 years	1(12.5%)	2(9.1%)	16(22.2%)	7(10.4%)
Duration of illness				
< 12 months	3(37.5%)	8(36.4%)	42(58.3%)	36(53.7%)
12–24 months	3(37.5%)	3(13.6%)	11(15.3%)	18(26.9%)
> 24 months	2(25.0%)	11(50.0%)	19(26.4%)	13(19.4%)
Wilkes stage				
II	0	2(9.1%)	5(6.9%)	5(7.5%)
III	6(75.0%)	10(45.5%)	38(52.8%)	40(59.7%)
IV	2(25.0%)	7(31.8%)	25(34.7%)	20(29.9%)
V	0	3(13.6%)	4(5.6%)	2(3.0%)
Parafunctional habits				
Yes	8(100.0%)	15(68.2%)	37(51.4%)	39(58.2%)
No	0	7(31.8%)	35(48.6%)	28(41.8%)
Splint/Orthodontic therapy				
Yes	5(62.5%)	17(77.3%)	39(54.2%)	36(53.7%)
No	3(37.5%)	5(22.7%)	33(45.8%)	31(46.3%)

Clinical outcomes. MIO significantly improved from preoperative measurement to the final postoperative visit [median, range: 30 mm (28–32 mm) to 36.5 mm (33.42-38 mm)], while TMJ pain VAS scores

significantly decreased [median, range: 5 (4–6) to 0.50 (0.00-1.50)]. The other outcomes including diet VAS score [median, range: 4 (3.0–5.00) to 1 (1.0-1.67)] and QOL VAS score [median, range: 3 (2.0–3.0) to 4 (3.5-4.0)] were also significantly improved, (all P < 0.001) as demonstrated in Table 2 and Fig. 4.

Table 2
Clinical outcomes of TMJ arthroscopic disc repositioning and suturing.

Variables	**Follow-up visits Median (range)**		
	Pre-operative	**Post-operative (final visit)**	***P*-value**
MIO	30.0 (28.0–32.0)	36.5 (33.42-38.0)	< 0.001
Pain	5.0 (4.0–6.0)	0.50 (0.00-1.50)	< 0.001
Diet	4.0 (3.0–5.00)	1.0 (1.0-1.67)	< 0.001
QOL	3.0 (2.0–3.0)	4.0 (3.50-4.0)	< 0.001
(Wilcoxon signed ranked test)			

Radiological outcomes. Wilcoxon signed ranked test showed a statistically significant difference in the median quantitative measurement of condylar disc position before and immediately after surgery ($P < 0.01$), indicating successful disc repositioning. However, the disc position differences between the first and last postoperative visits were statistically insignificant (P = 0.698), therefore, a stable disc position through the whole postoperative period was affirmed. Meanwhile, the condylar height differences before and immediately after surgery as well as initial and final visits following surgery were all statistically significant (P < 0.01) (Table 3). Successful and stable disc repositioning was revealed in 161 patients (95.26%) evidenced on MRI examination at various follow-up visits (Fig. 5).

Table 3. Changes in disc position and condylar height pre- and postoperatively.

Variables	**Follow-up visits** Median (range)		
	Pre-operative	Post-operative (initial visit)	Post-operative (final visit)
Disc position	7.85(6.80,8.93) ***	-6.40(-5.60,-7.13)	-6.20(-5.70,-7.30)
Condylar height	21.85(19.50,24.23) ***	22.40(20.85,24.73)	24.60(22.30,26.82) ***

*** $P<0.001$ (Wilcoxon signed ranked test).

Analysis of variance (ANOVA) showed a statistically significant difference in the mean condylar disc position before and after surgery. Also, the LSD post hoc analysis showed statistically significant difference in the disc position among various Wilkes stages (table S1 & S2).

Prognostic variables and surgical outcomes. The multinomial regression analysis in an unadjusted manner revealed that patients aged from 11 to 15 years old (OR: 0.20, 95% CI: 0.06 to 0.69, $P = 0.01$) were significantly more likely to be in the good outcome group. Also, patients with shorter duration of illness (OR: 0.29, 95% CI: 0.08 to 0.97, $P = 0.04$); were more likely to be in the improved outcome group. Finally, patients with Wilkes stage III (OR: 0.11, 95% CI: 0.01 to 0.98, $P = 0.04$) were significantly associated with improved outcomes. Gender and parafunctional habits were found to be insignificant variables for the surgical outcomes. Meanwhile, a preferred result (improved outcome) was yielded in patients with postoperative splint/orthodontic therapy (OR: 0.28, 95% CI: 0.07 to 1.09, $P = 0.06$), as shown in Table 4.

Table 4
Multinomial analysis (unadjusted) with prognostic variables and surgical outcomes of the arthroscopic TMJ disc repositioning and suturing.

Variables	Poor Versus Excellent			Improved Versus Excellent			Good Versus Excellent		
	OR	95% CI	*P* value	OR	95% CI	*P* value	OR	95% CI	*P* value
Gender									
Female	Reference								
Male	NA			NA			1.15	0.39–3.38	0.794
Age group									
11–15 Y	0.86	0.03–24.15	0.934	0.69	0.08–5.83	0.739	0.20	0.06–0.69	0.011*
16–20 Y	5.66	0.26-121.62	0.268	1.29	0.20–8.41	0.785	0.49	0.16–1.49	0.213
21–25 Y	1.46	0.07–29.20	0.801	4.36	0.60-31.59	0.144	0.40	0.11–1.52	0.182
> 25 Y	Reference								
Duration of illness									
< 12 M	0.29	0.03–2.63	0.276	0.29	0.08–0.97	0.046*	1.02	0.42–2.50	0.954
12–24 M	2.50	0.24–25.97	0.442	0.27	0.05–1.37	0.117	0.43	0.14–1.29	0.135
> 24 M	Reference								
Wilkes Stage									
II	NA			0.54	0.03–9.26	0.673	0.37	0.03–3.48	0.385
III	NA			0.11	0.01–0.98	0.049*	0.32	0.05–2.11	0.239
IV	NA			0.22	0.02–1.92	0.173	0.61	0.09–3.97	0.608
V	Reference								
Parafunctional habits									
Yes	Reference								

OR- Odds ratio; CI- Confidence interval; NA- Not available/no patient; ; Y-years; M- months; *statistically significant

Variables	Poor Versus Excellent			Improved Versus Excellent			Good Versus Excellent		
	OR	95% CI	*P* value	OR	95% CI	*P* value	OR	95% CI	*P* value
No	NA			1.57	0.41–5.94	0.591	1.76	0.76–4.08	0.186
Splint/Orthodontic therapy									
Yes	Reference								
No	1.883	0.30-11.61	0.495	0.28	0.07–1.09	0.068	0.99	0.47–2.12	0.998

OR- Odds ratio; CI- Confidence interval; NA- Not available/no patient; ; Y-years; M- months; *statistically significant

Similarly, when adjusting the multinomial regression analysis for preoperative clinical outcome parameters (MIO, Pain, Diet and QOL), patient's age group from 11 to 15 years old (OR: 0.20, 95% CI: 0.05 to 0.78, $P = 0.02$), Wilkes stage III (OR: 0.23, 95% CI: 0.06 to 0.85, $P = 0.02$) and duration of illness less than 12 months (OR: 0.07, 95% CI: 0.008 to 0.74, $P = 0.02$) were still significant (Table 5).

Table 5
Multinomial analysis (adjusted) with prognostic variables and surgical outcomes of the arthroscopic TMJ disc repositioning and suturing.

Variables	Poor Versus Excellent			Improved Versus Excellent			Good Versus Excellent		
	OR	95% CI	*P* value	OR	95% CI	*P* value	OR	95% CI	*P* value
Gender									
Female	Reference								
Male	0.50	0.01–15.26	0.694	0.43	0.04–4.77	0.499	1.39	0.42–4.54	0.580
Age group									
11–15 Y	0.72	0.04–10.89	0.815	1.07	0.12–9.06	0.946	0.20	0.05–0.78	0.021*
16–20 Y	0.92	0.07–10.92	0.948	1.49	0.20-10.89	0.693	0.38	0.11–1.32	0.129
21–25 Y	0.98	0.08–11.87	0.991	4.96	0.60-41.04	0.137	0.35	0.08–1.56	0.172
> 25 Y	Reference								
Duration of illness									
< 12 M	0.42	0.05–3.44	0.421	0.23	0.06–0.85	0.028*	0.98	0.35–2.73	0.972
12–24 M	4.38	0.41–39.19	0.186	0.42	0.07–2.55	0.352	0.60	0.16–2.19	0.446
> 24 M	Reference								
Wilkes Stage									
II	0.56	0.002–156.42	0.843	0.23	0.01–4.88	0.348	0.32	0.02–4.26	0.393
III	4.43	0.05-370.87	0.510	0.07	0.008–0.74	0.026*	0.44	0.05–3.60	0.451
IV	1.26	0.01-110.13	0.919	0.14	0.01–1.37	0.093	0.76	0.09–5.95	0.797
V	Reference								
Parafunctional habits									

OR- Odds ratio; CI- Confidence interval; Y-years; M- months.

*statistically significant

Variables	Poor Versus Excellent			Improved Versus Excellent			Good Versus Excellent		
	OR	95% CI	*P* value	OR	95% CI	*P* value	OR	95% CI	*P* value
Yes	Reference								
No	0.27	0.03–2.25	0.227	2.39	0.58–9.83	0.225	2.09	0.77–5.67	0.145
Splint/Orthodontic therapy									
Yes	Reference								
No	1.53	0.28–8.35	0.621	0.48	0.12–1.85	0.287	1.21	0.50–2.91	0.662
OR- Odds ratio; CI- Confidence interval; Y-years; M- months.									
*statistically significant									

Discussion

Since the original introduction of Yang's arthroscopic disc repositioning technique for management of ADD, the technique has long been evaluated in previous reports revealing various range of success rates; 98.07–98.56%[13,8]. In order to optimize the outcomes of such treatment modality and achieve successful outcomes, different prognostic variables impacting the results of the arthroscopic technique are important to analyze. The selection of patients who would most likely benefit from a specified treatment option can be improved by having distinct research-based diagnostic criteria and strict selection principles based on the diagnoses. In addition, a correct identification of radiological and patient-based specific factors are important to guide the surgeons to predict treatment outcomes and to suggest the patient an overview into the possible benefits of the proposed treatment. The optimization of patient selection and thereby improved treatment outcomes can also prevent an unnecessary treatment for those who would not benefit. To meaningfully obtain this, individualized predictors of treatment outcomes are a prerequisite[21]. In the current study, we analyzed the different prognostic factors impacting the clinical and radiological outcomes of the arthroscopic disc repositioning and suturing technique, revealing that age, duration of illness, and Wilkes staging were the most significant predictors for successful surgical outcomes.

From the results of the current study, a total success rate of 95.26% was revealed in our series, which was comparable with our previous reports[8,13]. The study confirmed that younger age patients with shorter preoperative disease history and Wilkes stage III were most significantly associated with favorable clinical and radiological outcomes following TMJ arthroscopic disc repositioning and suturing.

Our results showed no significant differences in the surgical outcomes in correlation to the gender variable although there was a tendency towards better results in the male group. It cannot be excluded

that the current study is under-powered in terms of this specific parameter due to the low number of male patients included. A large scale study is therefore required to fully explore the question of outcome in relation to gender.

Considering the age variable, the multinomial regression analysis revealed that younger age patients were significantly associated with excellent outcomes following the arthroscopic surgery, which was consistent with the results in our previous study[8]. However, such results were not in line with the reports of Cho et al. and Guarda-nardini et al.[22,23] concluding that older age subjects were the most benefiting from an arthroscopic surgery in advanced disease stages, however, the former classified patients into two groups based on age; below and above 40 years, and both reports only analyzed the outcomes following the operative arthroscopy without specifying disc suturing. Contrary, a retrospective cohort analyzing the age as the primary predictor variable, revealed that age showed no impact on the outcomes following arthroscopic surgery[15]. In our study, age showed a significant impact on the outcomes which can be related to the fact that the retrodiscal tissues and adjacent articular structures are soft and resilient in younger age patients making the anterior release, disc recapture and suturing procedures more easier to handle than in elderly patients with more stiff tissues.

In the current report, the authors used patient specific variables as an indicator of the surgical outcomes with the design of success criteria based on MIO, pain, diet and QOL. With this multi-variable analysis, the present study outcomes were more comprehensive and accurate, expressing the exact surgical results as it included various related factors rather than single variable. Ulmner et al.[24] in their retrospective report, settled the success criteria at MIO of $\geq$ 35 mm and pain score of $\leq$ 3 with a success rate of 67 %, without evaluation of diet or QOL, in addition, their report only investigated the outcomes following the arthroscopic lysis and lavage. The same research group prospectively analyzed the same patient specific variables, revealing that an associated preoperative bilateral masticatory tenderness was the most significant factor affecting the surgical outcomes[25].

Our results revealed that Wilkes stage III was associated with excellent outcomes based on the multinomial analysis, which was in accordance with the results advocated by previous reports. McCain et al.[26] in their prospective cohort longitudinal study, correlated the outcomes of TMJ arthroscopic disc suturing to different Wilkes stages, revealing a successful outcome in 69% of the included subjects and that Wilkes II and III stages showed the most successful outcomes. However, these findings were limited by the smaller sample size (32 subjects) and relatively shorter term follow up period (12 months). Similarly, Smolka et al.[27] reported that stages II and III were associated with successful outcomes than stages IV and V with an overall success rate of 78.3%, however limited to the arthroscopic lysis and lavage cases with smaller sample size of participants. Likewise, Bronstein and Merrill[28)] noticed higher success rates of arthroscopic surgery in the lower than in the advanced Wilkes stages. Alternatively, Murakami et al.[29] reported an equal impact of all Wilkes stages on the surgical outcomes following the arthroscopic surgery.

Furthermore, from the results of the multinomial regression analysis, the duration of disease course was revealed as a significant prognostic indicator impacting the surgical outcomes. Cai et al.[30] concluded that the more duration of disease was, the more shortening of the displaced disc and more anteriorly displaced followed by condylar degeneration. The severity of these degenerative changes might restrict alleviating the effects caused by disease and hence the surgical outcomes.

Reviewing the available literature, we found most reports evaluating different treatment modalities for management of TMJ illness using mainly clinical assessment tools, with fewer articles reporting the radiological assessment[8,14]. In the current research, we, for the first time, quantitatively assessed the disc displacement distance preoperatively versus the disc reposition distance postoperatively using MRI. More importantly, we demonstrated the stability of the disc position following surgery and through the longest follow up visit by the insignificant difference between the quantitative measurements at immediate and late postoperative follow ups, which is clearly more accurate than simply reporting the disc position with the conventional visual inspection method as reported in all previous studies[8,14]. Muñoz-Guerra et al.[17] applied the two circle method to quantitatively analyze disc position in MRI, however using angular rather than linear measurements as in our report.

Liu et al.[31] implemented a prognostic nomogram to predict the prognostic variables most associated with higher chances of successful disc repositioning, reflected by postoperative new bone formation and condylar remodeling as an important index of treatment outcome which can reverse the effects caused by ADD. They concluded that age of onset, nocturnal bruxism, disc morphology, bone marrow density, Wilkes stages, and postoperative splint therapy were significantly associated with bone remodeling after arthroscopic surgery. From the results of the current study, a preferred outcome was revealed in the condylar height difference between Wilkes stages IV and V ($P < 0.05$). Although there was such a significant difference in the condylar height between Wilkes IV and V, however this did not affect the sum results of correlation among different stages.

The current study presents several advantages including: 1) Identification of predictor variables is important for helping the treating surgeon to predict the surgical outcomes and to give the patient a fair view of the possible benefits of the suggested surgery, 2) This study acts as a template for case selection algorithm prior to the arthroscopic surgery. Still, the current research poses some limitations. First, this study was retrospective in design, meaning that weaknesses occur inherent for this study type. During the time period investigated, no formal examination protocol was used and therefore the data should be interpreted with caution. However, the findings may be of clinical value and as such calls for a verifying prospective study, which is currently ongoing. Second, although including a large sample size of participants, however, the male proportion was limited and therefore making the correlation with the gender invalid.

In conclusion, preoperative identification of patient specific variables is crucial for defining prognosis and guide surgeons for better patient selection. In addition, preoperative factors of older age, longer disease

history, and advanced Wilkes stages should alert the clinician that a lower chance for success may be at hand.

Declarations

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Author Contributions

M.K.S. and A.A participated in the study design, acquisition of data, analysis and interpretation of data, drafting and revising the manuscript for important intellectual content. C.Y. conceptualized and designed the study, critically reviewed and revised the manuscript, and approved the final manuscript as submitted. S.H.C helped with statistical analysis and results interpretation. P.S., Z.X.J. and Y.K.H. participated in the study design and the data collection. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Additional Information

Competing Interests: The authors declare no competing financial interests.

References

1. Oğütcen-Toller, M., Taşkaya-Yilmaz, N. & Yilmaz, F. The evaluation of temporomandibular joint disc position in TMJ disorders using MRI. *Int J Oral Maxillofac Surg*. **31**, 603–607 (2002).
2. Rammelsberg, P. et al. Variability of disk position in asymptomatic volunteers and patients with internal derangements of the TMJ. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. **83**, 393–399 (1997).
3. Zhou, Q. et al. Modified temporomandibular joint disc repositioning with miniscrew anchor: part II-stability evaluation by magnetic resonance imaging. *J Oral Maxillofac Surg*. **77**, 273-279 (2019).
4. American society of temporomandibular joint surgeons. Guidelines for diagnosis and management of disorders involving the temporomandibular joint and related musculoskeletal structures. *Cranio.* **21**, 68–76 (2003).
5. Sato, S., Sakamoto, M., Kawamura, H. & Motegi, K. Long-term changes in clinical signs and symptoms and disc position and morphology in patients with nonreducing disc displacement in the temporomandibular joint. *J Oral Maxillofac Surg*. **57**, 9–23 (1999).
6. Abramowicz, S. & Dolwick, M. F. 20-year follow-up study of disc repositioning surgery for temporomandibular joint internal derangement. *J Oral Maxillofac Surg*. **68**, 239–242 (2010).
7. Santos, T. S. et al. Effectiveness of disk repositioning and suturing comparing open-joint versus arthroscopic techniques: a systematic review and meta-analysis. Oral Surg Oral Med Oral Pathol Oral

Radiol. S2212-4403(21)00125-5 (2021). DOI: https://doi.org/10.1016/j.oooo.2021.02.015.

8. Abdelrehem, A. et al. Arthroscopic versus open disc repositioning and suturing techniques for the treatment of temporomandibular joint anterior disc displacement: 3-year follow-up study. Int J Oral Maxillofac Surg. 6:S0901-5027(21)00059-X (2021). doi: 10.1016/j.ijom.2021.02.018.
9. Israel, H. A. Technique for placement of a discal traction suture during temporomandibular joint arthroscopy. J Oral Maxillofac *Surg.***47**, 311-313 (1989).
10. Tarro, A. W. Arthroscopic treatment of anterior disc displacement: a preliminary report. J Oral Maxillofac Surg. **47**: 353-358 (1989).
11. Ohnishi, M. Arthroscopic surgery for hypermobility and recurrent mandibular dislocation. J Oral Maxillofac Surg Clin North Am. **1**: 153-156 (1989).
12. McCain, J. P., Podrasky A. E. & Zabiegalski N. A. Arthroscopic disc repositioning and suturing: A preliminary report. *J Oral Maxillofac Surg*. **50**, 568–579 (1992).
13. Yang, C., Cai, X. Y., Chen, M. J, & Zhang, S. Y. New arthroscopic disc repositioning and suturing technique for treating an anteriorly displaced disc of the temporomandibular joint: part I-technique introduction. *Int J Oral Maxillofac Surg*. **41**, 1058–1063 (2012).
14. Zhang, S. Y. et al. New arthroscopic disc repositioning and suturing technique for treating internal derangement of the temporomandibular joint: part II-magnetic resonance imaging evaluation. J Oral Maxillofac Surg. **68**, 1813–1817 (2010).
15. Muñoz-Guerra, M. F. et al. Is there a relationship between age, personal factors or surgical findings, and outcome after temporomandibular joint arthroscopy? *J Oral Maxillofac Surg*. **79**, 1000-1008 (2021).
16. Bengtsson, M. & Fransson, P. Do patient-reported outcome measures correlate with clinical follow-up after arthroscopic treatment of internal derangement of the temporomandibular joint? *J* Stomatol Oral Maxillofac Surg. S2468-7855(21)00048-3 (2021). doi: 10.1016/j.jormas.2021.03.003
17. Muñoz-Guerra, M. F. et al. Modified arthroscopic anterior myotomy for internal derangement of the temporomandibular joint: clinical and radiological results. *Int J Oral Maxillofac Surg*. **49**, 1311-1318 (2020)
18. Wilkes, C. H. Internal derangements of the temporomandibular joint. Pathological variations. *Arch Otolaryngol Head Neck Surg*. **115**: 469-477 (1989).
19. Markic, G. et al. Assessing the length of the mandibular ramus and the condylar process: a comparison of OPG, CBCT, CT, MRI, and lateral cephalometric measurements. *Eur J Orthod.* **37**, 13-21 (2015).
20. Xie, Q., Yang, C., He, D., Cai, X. & Ma, Z. Is mandibular asymmetry more frequent and severe with unilateral disc displacement? *J Craniomaxillofac Surg.***43**, 81-86 (2015).
21. Schiffman, E. et al. Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: recommendations of the international RDC/TMD consortium network and orofacial pain special interest group. *J Oral Facial Pain Headache*. **28**, 6–27 (2014).

22. Cho, J. & Israel, H. Does the age of a patient affect the outcome of temporomandibular joint arthroscopic surgery? *J Oral Maxillofac Surg*. **75**, 1144-1150 (2017).
23. Guarda-Nardini, L. et al. Treatment effectiveness of arthrocentesis plus hyaluronic acid injections in different age groups of patients with temporomandibular joint osteoarthritis. *J Oral Maxillofac Surg*. **70**, 2048-2056 (2012).
24. Ulmner, M., Kruger-Weiner, C. & Lund, B. Patient-specific factors predicting outcome of temporomandibular joint arthroscopy: A 6-year retrospective study. *J Oral Maxillofac Surg*. **75**, 1643.e1-1643.e7 (2017).
25. Ulmner, M., Weiner, C. K. & Lund, B. Predictive factors in temporomandibular joint arthroscopy: a prospective cohort short-term outcome study. *Int J Oral Maxillofac Surg*. **49**, 614-620 (2020).
26. McCain, J. P., Hossameldin, R. H., Srouji, S. & Maher, A. Arthroscopic discopexy is effective in managing temporomandibular joint internal derangement in patients with Wilkes stage II and III. *J Oral Maxillofac Surg.***73**, 391–401 (2015).
27. Smolka, W. & Iizuka, T. Arthroscopic lysis and lavage in different stages of internal derangement of the temporomandibular joint: correlation of preoperative staging to arthroscopic findings and treatment outcome. *J Oral Maxillofac Surg*. **63**, 471-478 (2005).
28. Bronstein, S. L. & Merrill, R. G. Clinical staging for TMJ internal derangement: application to arthroscopy. *J Craniomandib Disord*. **6**, 7-15 (1992).
29. Murakami, K. I. et al. Outcome of arthroscopic surgery to the temporomandibular joint correlates with stage of internal derangement: Five-year follow-up study. *Br J Oral Maxillofac Surg.* **36**, 30-34 (1998).
30. Cai, X. Y., Jin, J. M. & Yang, C. Changes in disc position, disc length, and condylar height in the temporomandibular joint with anterior disc displacement: a longitudinal retrospective magnetic resonance imaging study. *J Oral Maxillofac Surg*. **69**, e340-e346 (2011).
31. Liu, X. et al. A prognostic nomogram for postoperative bone remodeling in patients with ADDWoR. *Sci Rep*. **8**, 1-8 (2018).

Figures

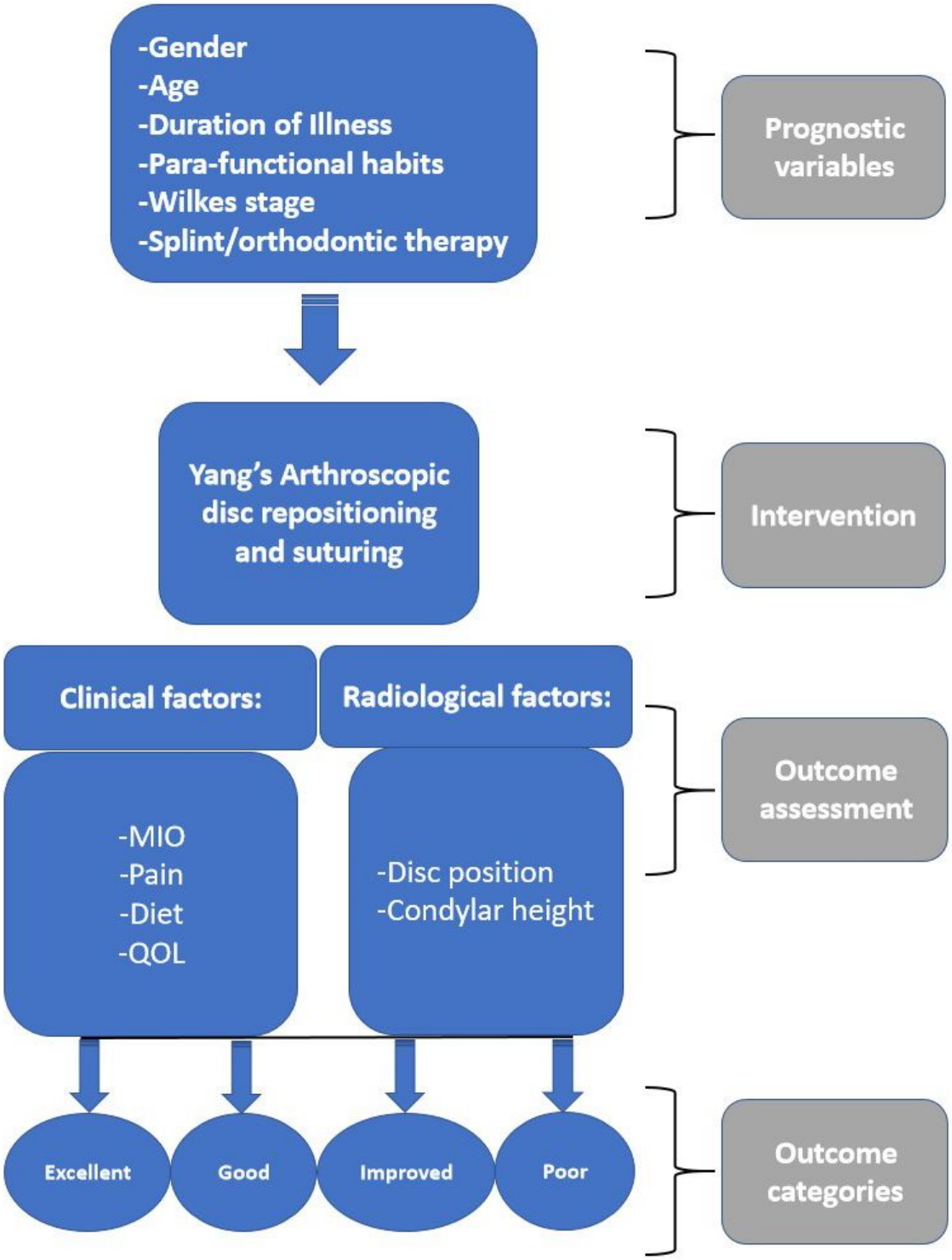

Figure 1

Study design and workflow analysis of prognostic variables.

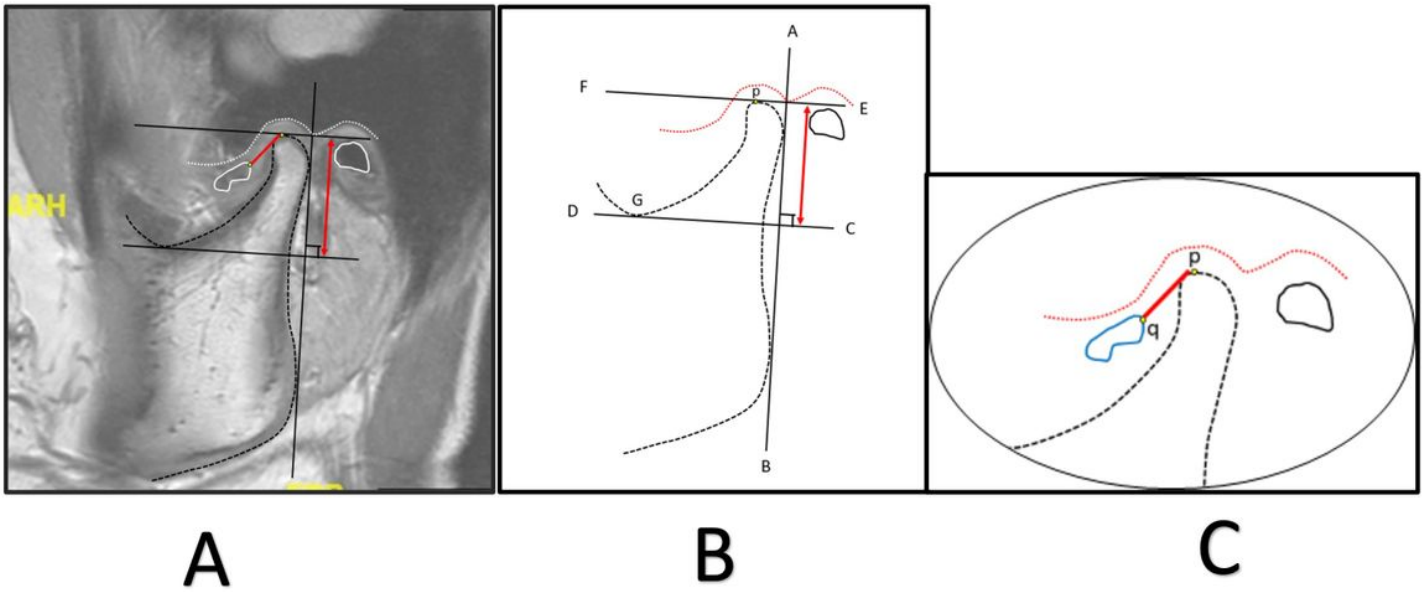

Figure 2

An illustrated diagram demonstrating the key reference points on MRI measurements before surgery. (A): A preoperative MRI sagittal view, (B): A schematic diagram showing reference points and lines for condylar height measurement, (C): A schematic diagram demonstrating reference points and lines for measurement of disc displacement distance.

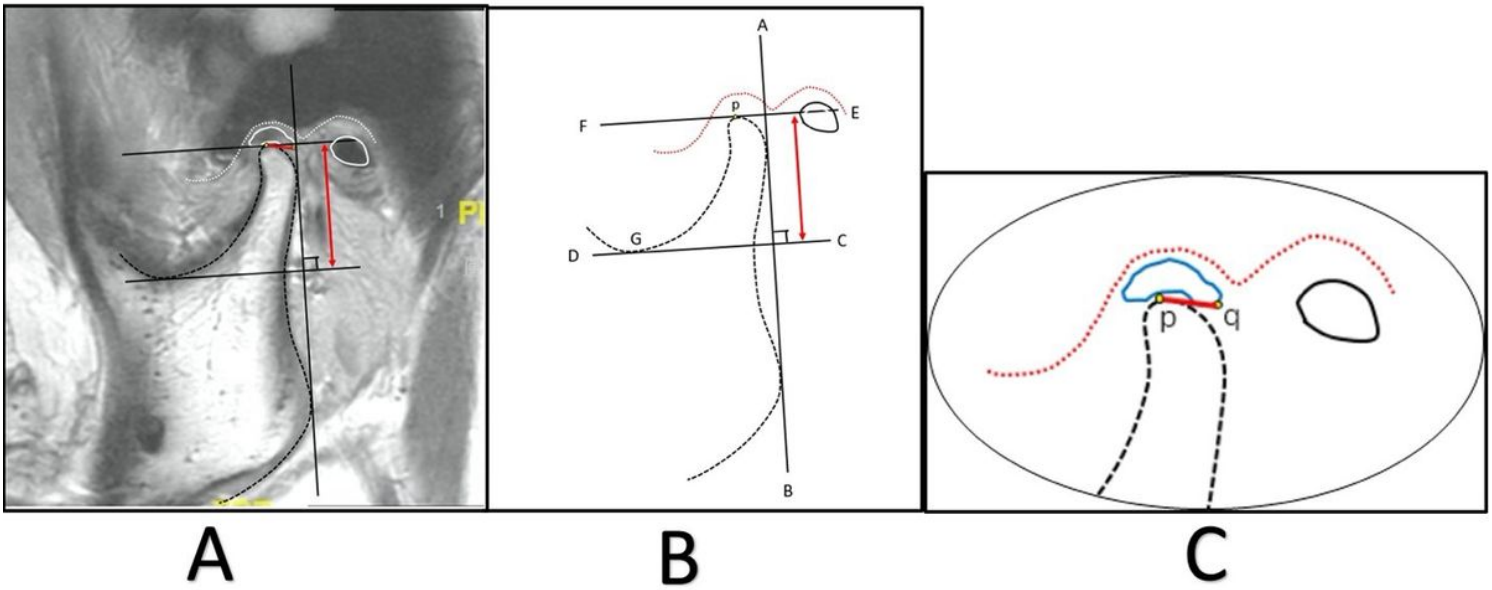

Figure 3

An illustrated diagram demonstrating the key reference points on MRI measurements after surgery. (A): A postoperative MRI sagittal view, (B): A schematic diagram showing reference points and lines for

condylar height measurement, (C): A schematic diagram demonstrating reference points and lines for measurement of disc reposition distance.

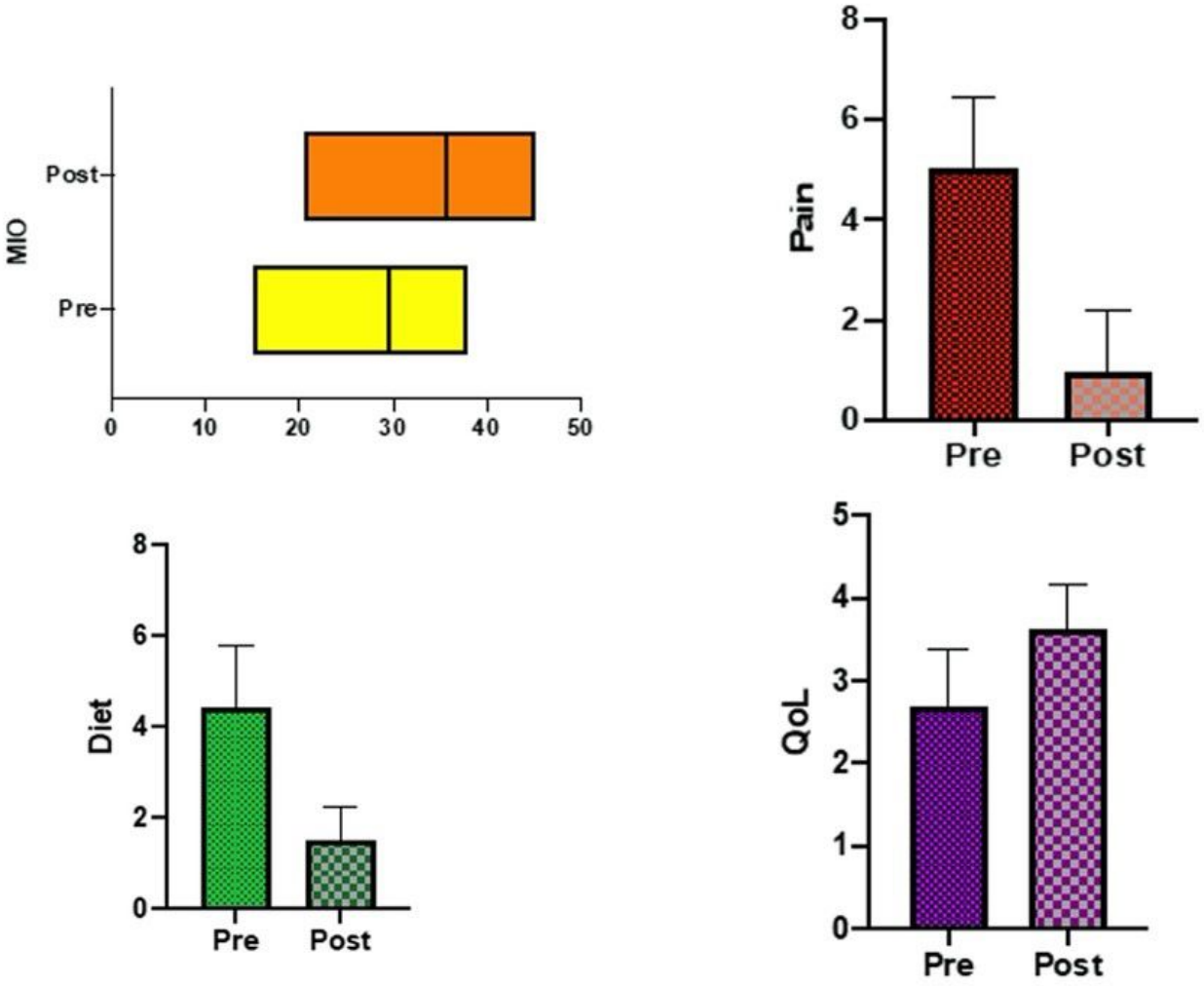

Figure 4

Clinical outcomes of TMJ arthroscopic disc repositioning and suturing. MIO significantly increased (median, range: 30 mm (28-32 mm) to 36.5 mm (33.42-38 mm), TMJ pain VAS score decreased (median, range: 5 (4-6) to 0.50 (0.00-1.50), diet VAS score improved (median, range: 4 (3.0-5.00) to 1 (1.0-1.67) and QOL score also improved (median, range: 3 (2.0-3.0) to 4 (3.5-4.0), P <0.001.

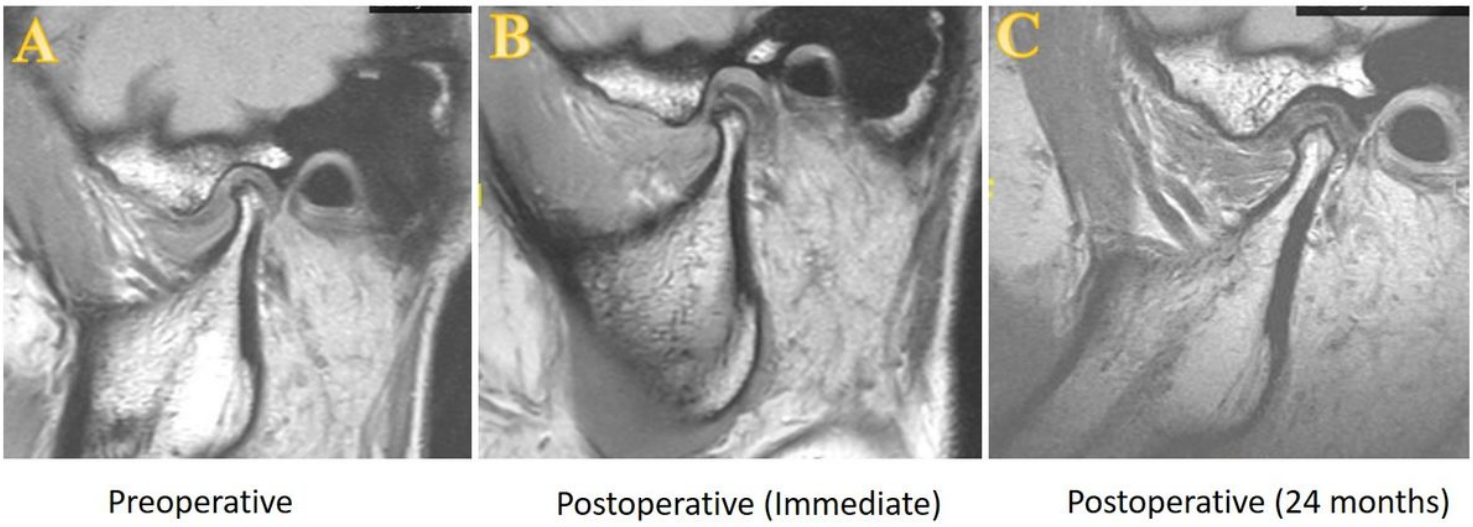

Figure 5

MRI scans of a 17-year-old female patient with ADD on the left side. (A) Preoperative MRI image, (B) Immediate postoperative MRI image showing successful disc repositioning, (C) Stable disc position with condylar bone remodeling at 24 months of postoperative follow-up.

Supplementary Files

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