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Effect of duration of preoperative pain on outcomes of total temporomandibular joint replacement

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Abstract

The purpose of the study was to determine whether the duration of preoperative pain affects outcomes of temporomandibular joint replacement (TMJR). Twenty-seven patients who underwent primary TMJR between 1 July 2020 and 31 October 2022 were retrospectively assessed for duration of preoperative pain, level of preoperative and postoperative pain on a visual analogue scale (VAS; 0, none; 10, severe), preoperative and postoperative range of motion (ROM), and net change in quality of life (much better, better, same, worse, much worse), reporting the longest available follow up for each patient. Surgical success was defined as postoperative pain of $\leq$4 and postoperative ROM of $\geq$30 mm, or net change (Δ) in ROM of $\geq$10 mm. Regression analyses evaluated associations between independent variables and postoperative pain and ROM. At a mean follow-up of 17.8 (SD: 6.8, range 3-32) months , pain (5.1, SD: 2.2, $p < 0.001$) and ROM (9.3 mm, SD: 8.0, $p<0.001$) significantly improved. Quality of life was much better in 16 patients, better in eight, the same in one, and worse in two. Longer duration of preoperative pain tended to be negatively associated with postoperative ROM ($\beta = -0.27$; 95% CI -0.6 to 0.0; $p = 0.078$) but was not associated with severity of postoperative pain. Surgical success was achieved in 23/27 patients. The successful group tended to have lower pain on VAS preoperatively (5.9, SD: 1.9) vs 7.5, SD: 1.3) and postoperatively (0.4, SD: 0.8 vs 4.8, SD: 2.6), and greater improvement in quality of life (much better: 14/23 vs 2/4). In conclusion, longer duration of preoperative pain tended to be associated with worse postoperative ROM following TMJR. Higher preoperative pain may be a predictor for unsuccessful surgery.

Keywords: Total temporomandibular joint replacement; Temporomandibular joint arthrogenous disorder; Preoperative pain duration; Postoperative pain; Postoperative range of motion

Introduction

Temporomandibular joint (TMJ) arthrogenous disorders can be treated by conservative methods (medications, occlusal appliances, physiotherapy, behavioural therapy), minimally invasive procedures (intra-articular injections, arthrocentesis, arthroscopy) and/or open surgery (discoplasty, discectomy, arthroplasty, joint replacement).[1] Total temporomandibular joint replacement (TMJR) is an established treatment with good outcomes,[2–7] and is reserved for patients with end-stage TMJ disorders.[8–10]

The optimal timing of TMJR is surrounded by controversy, as patients typically first undergo conservative, and then sometimes minimally-invasive treatments.[1] Gerber and Saeed[11] and Linsen et al[12] found that patients with worse preoperative pain were more at risk of developing moderate to severe chronic postoperative pain, which could be related to the progression of the disorder. Therefore, it is important to determine whether patient characteristics, especially dura-

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tion of preoperative pain, affect the surgical outcomes of TMJR.

To our knowledge, only one study has evaluated the effect of duration of preoperative pain on the outcomes of TMJR, reporting that preoperative pain that lasts for more than two years increases the risk of chronic postoperative pain.[13] However, the authors arbitrarily categorised preoperative pain into two groups (<2 years and >2 years). In contrast, three studies[14–16] that analysed duration of preoperative symptoms in general reported no clear effect on the outcomes of TMJR. The aim of the present study therefore was to determine whether the duration of preoperative pain affects clinical outcomes following TMJR.

Methods

The authors retrospectively assessed all patients who underwent primary TMJR with (n = 2) or without (n = 25) associated orthognathic surgery between July 2020 and October 2022. Operations were performed by the senior surgeon (AS Cousin) using either stock or custom TMJ prostheses (Zimmer Biomet) (n = 27). Indications for TMJR were: (i) adult patients aged ≥18 years; (ii) stage 5 in Dimitroulis classification;[17] (iii) TMJ articular pain ≥4 on a visual analogue scale (VAS), and/or chewing issues, and/or a TMJ range of motion (ROM) of <35 mm; and (iv) a minimum of three months of conservative treatment (physiotherapy, occlusal appliances, and/or painkillers).

The present study was approved by the institutional review board of CHU Lyon Sud (CSE-HCL – IRB 00013204, approval number 23-5278). Patients provided informed consent for their data to be used for research and publication purposes.

Patients' records were retrospectively evaluated for demographics, aetiology, previous TMJ surgeries, specific comorbidities (psychiatric, rheumatic, neurological), duration of pain since first appearance, preoperative and postoperative pain on VAS (0: no pain; 10: excruciating pain), preoperative and postoperative ROM (vertical distance between maxillary and mandibular central incisors), duration of follow up, complications, and postoperative quality of life, which were all collected as part of routine clinical practice. Quality of life was assessed using a TMJ surgery focused questionnaire (TMJ-S-QoL with 8 domains scored separately) created by Dimitroulis et al[18] and modified by Gupta et al,[19] which evaluated postoperative pain (1: none; 5: severe), diet and chewing (1: able to chew everything; 5: only blended foods), speech (1: normal; 5: cannot be understood), recreation (1: no limitations; 5: totally limited), mood (1: excellent; 5: extremely depressed), anxiety (1: none; 4: severe), main issues (up to 3 from the previous categories), and overall quality of life (1: excellent; 6: very poor). Patients were also asked to retrospectively evaluate their preoperative diet and chewing using the TMJ-S-QoL (1: able to chew everything; 5: only blended foods), and to evaluate their change in quality of life (much better, better, same, worse, much worse). Of note, no other preoperative TMJ-S-QoL subcomponents were recorded postoperatively, as they were deemed harder to evaluate retrospectively. The preoperative and postoperative clinical evaluations were performed by the operating surgeon. All postoperative data corresponded to the longest available follow up for each patient.

Statistical analysis

Descriptive statistics were used to summarise the data, including mean, standard deviation, median and range for continuous variables, and proportions and percentages for categorical variables. The surgery was considered successful if postoperative pain on VAS was ≤4 and either postoperative ROM was ≥30 mm or the net change (Δ) in ROM (postoperative – preoperative) was ≥10 mm, similar to Handa et al.[14] Patients were stratified into two groups (successful vs unsuccessful) according to these criteria. Differences between the two groups were assessed by calculating mean differences for continuous variables and risk differences for categorical variables, both with their corresponding 95% confidence intervals (CI). Differences between preoperative and postoperative values were assessed with the t-test (normally distributed) or Wilcoxon test (not normally distributed) for continuous variables, and the chi-squared test for categorical variables. Normality of distribution of continuous variables was assessed with the Shapiro-Wilk test. Univariable linear regression analyses were performed to determine associations of two continuous outcomes (postoperative TMJ ROM and postoperative pain) with independent variables (age, operated side, psychiatric comorbidities, rheumatic comorbidities, preoperative pain, duration of preoperative pain, preoperative ROM, preoperative diet and chewing). Associations were presented as regression estimates (β) with their corresponding 95% CI and p values. The following independent variables were not included in univariable regression analyses due to an insufficient number of patients (fewer than five) in one or more of their subgroups:sex, previous TMJ surgery, type of prosthesis, aetiology, and neurological comorbidities. Linear univariable regression models were deemed sufficiently powered considering the recommendations of Austin and Steyerberg[20] of a minimum of two subjects per variable (SPV). Statistical analyses were conducted using R version 4.3.1 (R Foundation for Statistical Computing).[21] P values of <0.05 were considered statistically significant.

Results

Patient demographics and surgical data

The cohort comprised a consecutive series of 27 patients (33 joints; one man and 26 women; aged 51 (SD: 15.7) years (Table 1). The aetiologies of the TMJ disorders were degenerative disease in 17 patients, autoimmune/rheumatic disease in three, infectious osteitis in two, fracture in two, idiopathic condylar resorption in one, chondrocalcinosis in one, and

Table1
Patient demographics.

	All patients (n=27)		Successful (n=23)		Unsuccessful (n=4)		Differences†	
	No./ mean (SD)	Median (range)	No. / mean (SD)	Median (range)	No. / mean (SD)	Median (range)	MD RD	95% CI
Age (years)	51.0 (15.7)	50.9 (20.2–80.1)	51.3 (16.9)	51.5(20.2–80.1)	49.4 (6.2)	48.6 (43.0–57.3)	1.9	(-7.3 to 11.0)
Sex: female	26		22		4		0.0	(-0.2 to 0.1)
Operated side:								
Right	8		6		2		0.2	(-0.5 to 1.0)
Left	13		12		1		-0.3	(-0.9 to 0.4)
Bilateral	6		5		1		0.0	(-0.6 to 0.7)
Previous TMJ surgery	4		4		0		-0.2	(-0.1 to 0.5)
Custom prosthesis	2		2		0		-0.1	(-0.1 to 0.3)
Orthognathic surgery	2		2		0		-0.1	(-0.1 to 0.3)
Aetiology:								
Degenerative (arthrosis)	17		14		3		0.1	(-0.4 to 0.7)
Autoimmune/rheumatic	3		3		0		-0.1	(-0.3 to 0.0)
Infectious (osteitis)	2		2		0		-0.1	(-0.2 to 0.0)
Traumatic	2		1		1		0.2	(-0.3 to 0.7)
Condylar resorption	1		1		0		0.0	(-0.1 to 0.0)
Childhood fracture with ankylosis	1		1		0		0.0	(-0.1 to 0.0)
Chondrocalcinosis	1		1		0		0.0	(-0.1 to 0.0)
Comorbidities:								
Psychiatric:							0.0	(-0.5 to 0.5)
Depression	3		2		1			
Sleep disorders	4		4		0			
Other	1		1		0			
Rheumatic:							-0.1	(-0.5 to 0.6)
Chronic back pain	3		3		0			
Other pain syndromes	1		1		0			
Other	5		4		1			
Neurological:							0.2	(-0.7 to 0.4)
Migraines	2		1		1			
Other	1		1		0			
Preoperative pain on VAS (no pain, 0; excruciating pain, 10)	6.1 (1.9)	6.0 (0–9)	5.9 (1.9)	6.0 (0–9)	7.5 (1.3)	7.5 (6–9)	-1.6	(-3.1 to 0.1)
Duration of preoperative pain (years)	8.1 (8.4)	4.2 (0–30)	7.6 (7.8)	4.0 (0–30)	10.9 (12.8)	5.4 (3–30)	-3.2	(-16.2 to 9.8)
Duration of preoperative pain ≥2 years (n)	22		18		4		0.2	(-0.5 to 0.1)
Preoperative TMJ ROM (mm)	22.8 (10.9)	25.0 (0–40)	23.2 (11.2)	25.0 (0–40)	20.3 (9.3)	20.5 (10–30)	3.0	(-7.3 to 13.2)
Preoperative diet and chewing from modified TMJ-S-QoL (best, 1; worst, 5)	3.1(1.4)	3.0 (1–5)	3.0 (1.4)	3.0 (1–5)	3.3 (1.3)	3.0 (2–5)	-0.3	(-1.6 to 1.1)

TMJ: temporomandibular joint; ROM: range of motion; VAS: visual analogue scale; TMJ-S-QoL: TMJ surgery-specific quality of life questionnaire; MD: mean difference; RD: risk difference; CI: confidence interval

†Difference between "successful" and" unsuccessful" groups

Table 2
Outcomes of TMJ replacement surgery (n = 27).

	All patients (n = 27)			"Successful" (n=23)			"Unsuccessful" (n = 4)			Differences†	
	Mean±SD	Median	(Range)	Mean±SD	Median	(Range)	Mean±SD	Median	(Range)	MD	(95% CI)
	n (%)			n (%)			n (%)			RD	
Follow up (months)	17.8±6.8	17.1	(3– 32)	18.5±7.1	22.3	(3– 32)	13.9±2.6	13.8	(11– 17)	4.6	(0.7– 8.4)
Complications	5.0(18.5%)			4 (17.4%)			1(25.0%)			0.1	(−0.6– 0.5)
TMJ ROM (mm)											
Postoperative	32.0±6.1	33.0	(20– 40)	33.0±6.5	34.0	(20– 47)	29.5±7.3	28.5	(22– 39)	3.5	(−4.2– 11.2)
Net change*	9.3±8.0	8.0	(−4– 24)	9.8±7.5	8.0	(0– 24)	9.3±11.8	8.5	(−4– 24)	0.5	(−11.4– 12.5)
Pain on VAS (no pain, 1; excruciating pain, 10):											
Postoperative	1.0±2.0	0.0	(0– 7)	0.4±0.8	0.0	(0– 3)	4.8±2.6	5.5	(1– 7)	−4.4	(−7.0– −1.8)
Net change*	5.1±2.2	5.0	(0– 9)	5.5±1.7	6.0	(0– 9)	2.8±3.4	2.0	(0– 7)	2.8	(−0.6– 6.2)
Modified TMJ-S-QoL											
Diet and chewing (best, 1; worst, 5)											
Preoperative	3.1±1.4	3.0	(1– 5)	3.0±1.4	3.0	(1– 5)	3.3±1.3	3.0	(2– 5)	−0.3	(−1.6– 1.1)
Postoperative	1.5±0.9	1.0	(1– 4)	1.3±0.7	1.0	(1– 4)	2.3±1.5	2.0	(1– 4)	−0.9	(−2.4– 0.6)
Net change*	−1.6±1.5	−1.0	(−4– 1)	−1.7±1.4	−1.0	(−4– 0)	−1.0±2.2	−0.5	(−4– 1)	−0.7	(−2.8– 1.5)
Postoperative pain (best, 1; worst, 5)	2.0±1.2	2.0	(1– 5)	1.7±0.8	2.0	(1– 4)	3.5±1.7	3.5	(2– 5)	−1.8	(−3.5– −0.1)
Postoperative speech (best, 1; worst, 5)	1.4±0.6	1.0	(1– 3)	1.3±0.6	1.0	(1– 3)	1.5±0.6	1.5	(1– 2)	−0.2	(−0.8– 0.5)
Postoperative recreation (best, 1; worst, 5)	1.3±0.7	1.0	(1– 4)	1.1±0.3	1.0	(1– 2)	2.5±1.3	2.5	(1– 4)	−1.4	(−2.6– −0.1)
Postoperative mood (best, 1; worst, 5)	1.8±1.0	2.0	(1– 5)	1.6±0.7	2.0	(1– 3)	2.8±2.1	2.5	(1– 5)	−1.1	(−3.2– 0.9)
Postoperative anxiety (best, 1; worst, 4)	1.5±0.7	1.0	(1– 3)	1.4±0.6	1.0	(1– 3)	2.0±1.2	2.0	(1– 3)	−0.6	(−1.7– 0.6)
Postoperative issues (up to 3 issues)	15 (55.6%)			11 (47.8%)			4 (100.0%)			0.5	(−0.9– −0.2)
Issues: pain	10 (37.0%)			7 (30.4%)			3 (75.0%)			0.4	(−1.0– 0.2)
Issues: diet and chewing	6 (22.2%)			4 (17.4%)			2 (50.0%)			0.3	(−1.0– 0.3)
Issues: speech	6 (22.2%)			5 (21.7%)			1 (25.0%)			0.0	(−0.5– 0.5)
Issues: recreation	1 (3.7%)			1 (4.3%)			0 (0.0%)			0.0	(−0.1– 0.2)
Issues: mood	1 (3.7%)			1 (4.3%)			0 (0.0%)			0.0	(−0.1– 0.2)
Issues: anxiety	6 (22.2%)			4 (17.4%)			2 (50.0%)			0.3	(−1.0– 0.3)
Overall quality of life (best, 1; worst, 6)	2.7±1.2	3.0	(1– 5)	2.5±1.0	2.0	(1– 5)	3.8±1.5	4.0	(2– 5)	−1.3	(−2.8– 0.3)
Change in quality of life (n=27)											
Much bettter	16 (59.3%)			14 (60.9%)			2 (50.0%)			−0.1	(−0.8– 0.6)
Better	8 (29.6%)			8 (34.8%)			0 (0.0%)			−0.3	(−0.6– −0.1)
The same	1 (3.7%)			1 (4.3%)			0 (0.0%)			0.0	(−0.1– 0.1)
Worse	2 (7.4%)			0 (0.0%)			2 (50.0%)			0.5	(−0.1– 1.1)
Much worse	0 (0.0%)			0 (0.0%)			0 (0.0%)			NA	

Abbreviations: TMJ, temporo−mandibular joint; ROM, range of motion; VAS, visual analogue scale; TMJ-S-QoL, TMJ Surgery specific quality of life questionnaire; MD, mean difference; RD, risk difference; CI, confidence intervals.

† Differences between "successful" and "unsuccessful" groups.

* Statistically significant improvement from pre- to post-operative values ($p<0.001$)

ankylosis secondary to childhood fracture in one. Four patients had had either one or two previous TMJ surgeries, including arthrocentesis, and discectomy and/or eminectomy with condyloplasty. Seven patients had psychiatric comorbidities, nine had rheumatic comorbidities, and three had neurological comorbidities (note that some patients had more than one of these). Preoperatively, pain on VAS was 6.1 (SD: 1.9, median, 6.0;range 0-9); mean duration of pain was 8.1 (SD: 8.4, median, 4.2; range, 0-30) years, mean ROM was 22.8 (SD: 10.9; median, 25.0; range 0-40) mm, and the diet and chewing subcomponent of the TMJ-S-QoL was 3.1(SD: 1.4; median, 3.0; range 1–5).

Of the 27 patients, 13 underwent left TMJR, eight right TMJR, and six bilateral TMJR. Two patients had custom prostheses due to substantial bone resection in the context of osteitis, while the other 25 had stock prostheses. Two patients had an associated orthognathic surgery (for idiopathic condylar resorption in one, and traumatic fracture in the other).

Clinical and functional outcomes

Five of the 27 patients had surgical complications. One case of intraoperative massive haemorrhage (stock prosthesis), treated by haemostasis with regional compression, may have resulted in nerve damage. This patient was still symptomatic for neuropathic pain 17 months postoperatively and was referred to a pain centre.

One case of early TMJ dislocation (stock prosthesis) at 72 hours postoperatively was treated by closed reduction and maxillomandibular fixation under general anaesthesia. At 22 months postoperatively, the patient had good outcomes (pain on VAS: 2 points; ROM: 30 mm, and diet and chewing subcomponent of the TMJ-S-QoL: 2 points).

One case of early periprosthetic *Staphylococcus epidermidis* infection (stock prosthesis) at one week postoperatively was treated by lavage and scrubbing of the prosthesis with a toothbrush and Betadine® solution, but without placement of a drain,[22] followed by three months of antibiotics. At 11 months postoperatively the patient had good outcomes (no pain; ROM: 30 mm; and diet and chewing subcomponent of the TMJ-S-QoL: 1 point).

There were two cases of unexplained pain and swelling at two (custom prosthesis) and 13 (stock prosthesis) months postoperatively. CT scans for both cases showed periprosthetic fluid collection, treated by lavage and scrubbing of the prostheses with a toothbrush and Betadine® solution but without placement of a drain,[22] followed by six weeks of antibiotics. However, bacterial cultures from the samples collected during reinterventions were negative and the patients recovered with no other treatment. The patient who presented the complication at two months postoperatively had good outcomes at 12-month follow up (no pain; ROM: 26 mm; and diet and chewing subcomponent of the TMJ-S-QoL: 1 point). The patient who presented the complication at 13 months postoperatively had good outcomes at the 24-month follow up (no pain on VAS; ROM: 35 mm; and diet and chewing subcomponent of the TMJ-S-QoL: 1 point).

At a mean follow up of 17.8 (SD: 6.8) months, pain on VAS was 1.0 (SD: 2.0;median 0.0; range 0-7), ROM was 32.0 mm (SD: 6.1;median 33.0; range 20–40), and the diet and chewing subcomponent of the TMJ-S-QoL was 1.5 (SD: 0.9; median 1.0; range 1–4) (Table 2). There was a significant improvement in pain on VASof −5.1 points (SD: 2.2; $p < 0.001$), in ROM of 9.3 mm (SD: 8.0, $p<0.001$), and in the diet and chewing subcomponent of the TMJ-S-QoL of −1.6 (SD: 1.5; $p < 0.001$). Quality of life was “much better” in 16 patients, “better” in eight, “the same” in one and “worse” in two.

Both patients with associated orthognathic surgery (performed for aesthetic reasons and orthodontic stability) achieved good postoperative outcomes (postoperative ROM: 30 mm and 40 mm, pain on VAS: 0 and 3 points, no diet and chewing limitations, and quality of life rated as “much better” than before surgery).

Univariable linear regression analyses showed that postoperative ROM decreased with age ($\beta = -0.18$; 95% CI −0.3 to 0; $p = 0.029$), but increased with preoperative ROM ($\beta = 0.41$; 95% CI 0.2 to 0.6; $p < 0.001$), and tended to decrease with longer duration of preoperative pain ($\beta = -0.27$; 95% CI −0.6 to 0.0; $p = 0.078$) and with worse preoperative diet and chewing ($\beta = -1.70$; 95% CI −3.5 to 0.1; $p = 0.065$) (Table 3). Furthermore, univariable linear regression analyses showed that postoperative pain was not associated with any of the examined independent variables, including duration of preoperative pain as either a continuous ($\beta = -0.02$; 95% CI −0.1 to 0.1; $p = 0.592$) or categorical variable (<2 years, >2 years) ($\beta = 1.03$; 95% CI −1.0 to 3.0; $p = 0.297$).

Successful vs unsuccessful groups

Of the 27 patients, 23 met the criteria for successful surgery. Preoperatively, the successful group tended to have lower pain on VAS preoperatively (5.9, SD: 1.9 vs 7.5, SD:1.3). Postoperatively, the successful group tended to have lower pain on VAS (0.4, SD:0.8 vs 4.8, SD:2.6), and lower pain on the TMJ-S-QoL (1.7, SD:0.8 vs 3.5, SD:1.7), as well as a better recreation score on the TMJ-S-QoL (1.1, SD:0.3 vs 2.5, SD:1.3), and greater improvement in quality of life (“much better” in 14/23 vs 2/4). Furthermore, the successful group tended to be less preoccupied by TMJ-related issues on the TMJ-S-QoL (11/23 vs 4/4).

Discussion

The present study has shown that TMJR provided good clinical outcomes for patients with TMJ arthrogenous disorders, with a surgical success rate of 23/27. The most important finding of the present study was that longer duration of preoperative pain tended to be associated with worse postoperative ROM, but it did not affect surgical success or postoperative pain. Higher preoperative pain may be a pre-

Table 3
Univariable regression analyses showing associations between two outcomes and all pertinent independent variables.

	Postoperative TMJROM (mm)			Postoperative pain on VAS		
	β[a]	(95% CI)	p value	β[a]	(95% CI)	p value
Age	-0.18	(-0.3 to 0.0)	0.029	-0.02	(-0.1 to 0.0)	0.453
Operated side:						
Right	1.46	(-4.8 to 7.7)	0.633	0.88	(-1.0 to 2.7)	0.331
Left	REF			REF		
Bilateral	-2.21	(-9.1 to 4.6)	0.513	0.72	(-1.3 to 2.7)	0.470
Comorbidities:						
Psychiatric	-2.12	(-8.5 to 4.2)	0.499	-0.05	(-1.9 to 1.8)	0.959
Rheumatic	-2.64	(-8.4 to 3.1)	0.353	0.66	(-1.0 to 2.4)	0.434
Preoperative pain on VAS (no pain, 0; excruciating pain, 10)	-0.33	(-1.8 to 1.1)	0.641	0.35	(-0.1 to 0.8)	0.095
Duration of preoperative pain (years)	-0.27	(-0.6 to 0.0)	0.078	-0.02	(-0.1 to 0.1)	0.592
Duration of preoperative pain ≥2 years	-3.58	(-10.3 to 3.1)	0.282	1.03	(-1.0 to 3.0)	0.297
Preoperative TMJ ROM (mm)	0.41	(0.2 to 0.6)	<0.001	-0.01	(-0.1 to 0.1)	0.866
Preoperative diet and chewing from modified TMJ-S-QoL (best, 1; worst, 5)	-1.70	(-3.5 to 0.1)	0.065	0.08	(-0.5 to 0.7)	0.782

TMJ: temporomandibular joint; ROM: range of motion; VAS: visual analogue scale; TMJ-S-QoL:TMJ surgery-specific quality of life questionnaire; β: regression coefficient; a: expected difference; CI: confidence interval

dictor of unsuccessful surgery. There was a tendency for worse preoperative function (ROM and diet and chewing) to be associated with worse postoperative ROM. A greater cohort is necessary to confirm these associations.

Overall, the outcomes of the present study were similar to those previously reported in the literature. The present study reported a postoperative ROM of 32.0 mm (SD: 6.1), similar to the findings in other studies, which range from 29.3–34.5 mm.[11,15,16,23] Two meta-analyses investigating the outcomes of different TMJ prostheses (both stock and custom)[2,3] reported a pooled increase in ROM for the Biomet prosthesis of 9.0 mm (95% CI 8.1 to 9.9) and 11.3 mm (95% CI 10.2 to 12.4), respectively, comparable to other included prostheses (Nexus CMF and Stryker/TMJ Concepts), and comparable to the increase in ROM of 9.3 mm (SD: 8.0) found in the present study. Furthermore, the present study reported postoperative pain on the VAS of 1.0 (SD: 2.0) points, which is comparable to the findings of Kanatsios et al[16] (1.1 points, SD:1.4) and considerably better than the findings of Gerber and Saeed[11] (2.1 points, SD: 2.6 and Sahdev et al[23] (3.9 points, SD: 2.7). The two aforementioned meta-analyses[2,3] reported a pooled reduction in pain for the Biomet prosthesis of -5.0 points (95% CI -5.3 to -4.7) and -3.2 points (95% CI -6.0 to -0.4), respectively, which is comparable to a reduction in pain of -5.1 points (SD: 2.2) found in the present study. Lastly, compared with the study by Gupta et al,[19] the present study reported worse postoperative pain (1.4, SD:1.0 vs 2.0, SD:1.2) and quality of life (1.7, SD:0.8 vs 2.7, SD:1.2) subcomponents of the TMJ-S-QoL, but similar results for the rest of the subcomponents.

Three published studies[14–16] reported that preoperative duration of symptoms was not associated with severity of postoperative pain, postoperative ROM, or surgical success. The present study found that preoperative duration of pain was not associated with severity of postoperative pain, but longer duration of preoperative pain tended to be associated with worse postoperative ROM. Furthermore, stratifying the cohort into "successful" and "unsuccessful" groups showed no mean difference in duration of preoperative pain between the groups. These results could be statistically significant in a larger cohort. Of note, the present study found that when the duration of preoperative pain was stratified into <2 years and ≥2 years, there was no association with severity of postoperative pain, which is in contrast to the results of Machoň et al.[13]

In patients with both advanced TMJ disease and dentofacial deformity, TMJR combined with orthognathic surgery is frequently recommended.[24–28] Previous studies[26,29] have shown that this results in favourable clinical outcomes, which is in accordance with the findings of the present study.

There are no validated criteria to define successful TMJR. Successful TMJ arthrocentesis has been defined by the American Association of Oral and Maxillofacial Surgeons Standards of Outcomes as ROM of >35 mm and pain on VAS of <3.[30] Since arthrocentesis is less invasive than TMJR and is performed in patients who are frequently in earlier stages of TMJ disease, Handa et al[14] proposed a combi-

nation of a ROM of ≥30 mm and pain on VAS of ≤4 to define successful TMJR. However, preoperative ROM for some patients could be zero or negligible, thus it may be unlikely for them to regain full TMJ mobility. Nonetheless, an increase in ROM due to TMJR could greatly improve their quality of life. Therefore, the present study defined TMJR as successful if postoperative pain on VAS was ≤4 and either postoperative ROM was ≥30 mm or net change in ROM was ≥10 mm.

Handa et al[14] did not evaluate patient-reported outcomes (PROs) which could have helped validate their surgical success criteria. The present study stratified the cohort into "successful" and "unsuccessful" groups and found a significant difference in the change in quality of life and in the recreation subcomponent of the TMJ-S-QoL between the groups; thus our surgical success criteria are associated with patient satisfaction. Given that as yet there are no validated criteria to define successful TMJR surgery, further studies should be performed to validate those that are available.

The present study found that preoperative pain tended to be higher in the "successful" group than in the "unsuccessful" group, confirming the findings of Gerber and Saeed and Handa et al.[11,14] Other studies have found that one or more of the following: previous TMJ surgeries, preoperative use of opioids, high preoperative pain, and low preoperative ROM, are predictive factors for poor outcomes of TMJR.[11,14,23] Two studies, however, found no associations between previous surgeries and TMJR outcomes.[13,16]

There is no clear consensus regarding the influence of comorbidities on the outcomes of TMJR. Two studies[13,14] reported a higher prevalence of positive psychiatric history in patients with poor TMJR outcomes, but without statistical significance. Sahdev et al[23] found that the presence of psychiatric comorbidity or chronic pain syndrome was linked to poor TMJR outcomes. The present study, however, found no associations between comorbidities and outcomes of TMJR.

The present single-centre retrospective study has a number of limitations. The small cohort size prevented the authors from performing multivariable regression analyses. This is because TMJR is a relatively rare surgery, and is used only for specific indications and in specialised centres. The only PRO recorded preoperatively was pain on VAS, while the preoperative diet and chewing subcomponent of the TMJ-S-QoL was collected retrospectively. The cohort was female-dominated, which is usual for this surgery,[9,13–16,23,31–33] given that chronic TMJ disorders are more prevalent in women.[8,34] The majority of the implanted prostheses were stock, which may not be representative of other surgeons' practices. However, a number of studies[3,6,35] have shown that stock and custom prostheses provide similar outcomes. The present study used the Dimitroulis surgical classification of TMJ disorders,[18] similarly to previously published studies,[14,16,36–39] although this classification has not been validated. Although univariable regression models were deemed sufficiently powered with a minimum of only two SPV,[20] higher numbers may be necessary to achieve adequate statistical power. Finally, six patients (6/27) underwent bilateral surgery, and they were analysed per patient and not per operated joint.

In conclusion, TMJR provided good clinical outcomes for patients with TMJ arthrogenous disorders, with a surgical success rate of 23/27. Higher preoperative pain may be a predictor of unsuccessful surgery. Furthermore, a longer duration of preoperative pain tended to be associated with worse postoperative ROM, but did not affect surgical success or postoperative pain.

Conflict of interest

First author receives consulting fees from Stryker. No conflicts of interest to declare for the other co-authors.

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Ethics statement/confirmation of patient permission

This study was approved by the institutional review board of CHU Lyon Sud on 26 December 2023 (CSE-HCL – IRB 00013204, approval number 23-5278). Patients provided informed consent for their data to be used for research and publication purposes.

CRediT author contribution statement

Anne-Sabine Cousin: Conceptualisation, Methodology, Resources, Investigation, Project administration, Supervision, Writing – review & editing. **Andrea Varazzani:** Resources, Investigation. **Emma Bach:** Resources, Investigation. **Kinga Michalewska:** Methodology, Data curation, Formal analysis, Writing – original draft, Visualisation, Writing – review & editing. **Sonia Ramos-Pascual:** Methodology, Data curation, Formal analysis, Writing – original draft, Visualisation, Writing – review & editing. **Mo Saffarini:** Resources, Supervision, Formal analysis, Writing – review & editing. **Alexis Nogier:** Funding acquisition, Supervision, Writing – review & editing.

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