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ORIGINAL ARTICLE

Pre-surgical radiographic and clinical features as predictors for temporomandibular joint discectomy prognosis

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Abstract

Objectives: This study aimed to identify potential clinical and radiological predictors associated with the outcome of discectomies.

Methods: In this retrospective observational study, the material comprised preoperative CBCT images and medical records of 62 patients with disc derangement disorders, who had undergone discectomy because of disc displacement with reduction (DDwR), disc displacement without reduction (DDwoR), systemic arthritis (SA), or joint hypermobility. Clinical and radiographic variables were analysed in relation to success rate determined by subjective, objective and combined outcomes.

Results: The success odds ratio was 11 times higher in patients with painful DDwR versus that of SA ($p = 0.03$), and even 25.9 times higher when considering solely objective outcome ($p = 0.03$). In the absence of subchondral pseudocyst, there were 5.2 times higher odds to have a successful subjective outcome ($p = 0.04$). Extensive bone apposition on the temporal joint component indicated a 9.3 times higher likelihood of a failed objective outcome ($p = 0.04$).

Conclusions: There is a significant higher risk for combined outcome failure for the diagnosis SA involving the TMJ compared with DDwR. Predictors of importance based on CBCT findings related to the objective outcome failure were extensive bone apposition on the temporal joint component and condylar subchondral pseudocysts for the subjective outcome failure.

KEYWORDS
cone-beam computed tomography, discectomy, prognosis, temporomandibular joint disorders, temporomandibular joint surgery

1 | INTRODUCTION

Temporomandibular disorders (TMD) are a common cause of discomfort in the orofacial region. This term comprises several conditions whose aetiology is multifactorial. These disorders can afflict the masticatory musculature and the osseous and soft tissue components of the temporomandibular joint (TMJ), including the articular disc and its ligaments (Barghan et al., 2012). The prevalence of TMD in the general population is 10%–30%, of which approximately 70% is related to a displacement of the TMJ disc, which can lead to

pain, joint clicking, locking of the joint and degeneration of the adjacent tissues (Farrar & McCarty, 1979; Hagandora & Almarza, 2012; Miloro & Henriksen, 2010).

Diagnosis and management of TMD require both clinical and imaging examinations. A variety of imaging modalities have been applied to image the TMJ, including magnetic resonance imaging (MRI), computed tomography (CT), CBCT, and conventional radiography such as panoramic imaging. For the diagnostics of soft-tissue abnormalities such as internal derangement in patients with TMD, MRI is the method of choice since it can depict disc, signs of synovitis as well as bone marrow oedema (Larheim et al., 2015). On the other hand, CBCT has emerged as a cost- and dose-effective imaging modality and is superior to MRI in detecting osseous changes in TMJ (Larheim et al., 2015), especially for the osseous changes in the temporal component (Alkhader et al., 2010).

The majority of patients with symptomatic disc displacement are treated successfully with non-surgical interventions, which may include patient education and self-care, pharmacotherapy, occlusal therapy, physiotherapy, behavioural therapy and psychotherapy (Dolwick, 1997; Widmark et al., 1994). It has been suggested that up to 20% of the patients do not respond fully to conservative treatment, and very few individuals, about 5% fail to respond to conservative therapy, which indicates subsequent surgical intervention (Dimitroulis & Dolwick, 1996; Dolwick & Dimitroulis, 1994). Reported surgical procedures that have been performed in conjunction with disc displacement are arthroscopy, discectomy with or without replacement, condylotomy, disc repair and disc repositioning (Abramowicz & Dolwick, 2010; Dimitroulis, 2005; Hall et al., 1993; Holmlund et al., 1993). Among these surgical procedures, discectomy without replacement has demonstrated high success rates in several follow-up studies (Bjørnland & Larheim, 2003; Dimitroulis, 2005; Eriksson & Westesson, 2001; Holmlund et al.,1993, 2013; Miloro and Henriksen, 2010). Nevertheless, about 10%–27% of discectomy were reported unsuccessful (Eriksson & Westesson, 1992, 2001; Holmlund & Axelsson, 1990; Holmlund et al., 1993, 2013; Molt et al., 2019; Nyberg et al., 2004). Very few studies have investigated, in particular, preoperative predictors for the outcome of discectomy. A study on discectomy without replacement indicated that patients with preoperative muscle symptoms were more prone to have residual symptoms (Holmlund et al., 1993). An unsuccessful outcome of discectomy seemed to correlate with patients diagnosed with the disc displacement without reduction (DDwoR) chronic closed lock without preceding clicking as compared to diagnoses of painful disc displacement with reduction (DDwR) (Holmlund et al., 2013). Miloro et al.reported that internal derangement classified as Wilkes stage VI was associated with an unsuccessful discectomy defined by maximal incisal opening (Miloro et al., 2017).

Identifying factors that could have an adverse influence on the prognosis of discectomy would facilitate the choice of therapeutic intervention and better prepare patients on the outcome of the coming surgical intervention. To our knowledge, no pre-surgical imaging predictors have been investigated for the prognosis of TMJ discectomy. The objective of the present retrospective cohort study was to investigate the possible association of preoperative radiographic and clinical features with the treatment outcome of discectomies.

2 | MATERIALS AND METHODS

2.1 | Ethical considerations

Ethical approval was received from the regional board in Stockholm prior to the onset of the study with the reference number Dnr 2013/1701-31/3 with an amendment dated 2015–04–15. The study was aligned with the Helsinki Convention and Good Clinical Practice.

2.2 | Study subjects

All referrals for pre-surgical CBCT during 2009 and 2012 were retrospectively reviewed, at the Department of Oral and Maxillofacial Surgery at Karolinska Institute. The inclusion criteria were patients who had not responded to previous conservative treatments, such as physical therapy, splint treatment, pharmacological therapy and stress management and referred for pre-surgical cone-beam computed tomography (CBCT) followed by discectomy without replacement. Exclusion criteria were patients who previously underwent TMJ open surgery. A history of injections of corticosteroids or hyaluronic acid was not an exclusion criterion.

2.3 | CBCT imaging and surgical procedure

The images were acquired with ProMax 3D (Planmeca Oy, Helsinki, Finland) and stored in Romexis (Planmeca Oy) applying the TMJ examination protocol according to the manufacturer at that time. The exposures were set at 90 kVp, 8 mA with a voxel size of 0.08 mm and a field of view of 4 × 4 × 5 cm. All CBCT images displayed on a RadiForce MX191 monitor (EIZO) were assessed by a general dentist, WM, who had received training on the interpretation of CBCT radiographs on TMJ and was calibrated with an oral radiologist, DB. From the CBCT volumes, axially corrected sagittal and coronal views were generated (Figure 1). Observers were blinded to clinical information.

The rationale for choosing discectomy as a surgical intervention was based on previous treatment algorithm (Holmlund, 2007; Holmlund et al., 2001). The operation was performed according to published description (Holmlund et al., 1993). A routine at the clinic was that all patients should be subjected to non-surgical conservative treatment prior to surgery. All patients were instructed to perform postoperative physiotherapy, which was continued until normal mouth opening capacity was obtained (typically six months postoperative) or until the last visit. The routine follow-up protocol was 1 week and 1, 3 and 6 months postoperative. The final follow-up

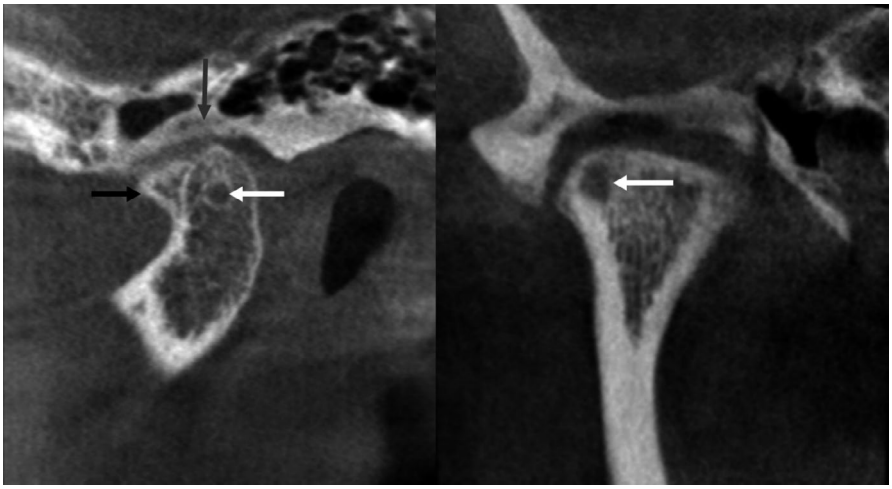

FIGURE 1 The image to the left shows bone apposition on the temporal joint component, as well as on the condyle, which also contains a subchondral cyst. The right image demonstrates a subchondral cyst within the condyle

period was in 42 out of 62 cases longer than 6 months either because of patient-related factors or on the initiative of the surgeon, because further follow-up was considered required.

2.4 | Study variables

2.4.1 | Predictor variable: Clinical features

Relevant clinical information on patients' gender, age at the radiographic examination, side of the affected TMJ, clinical diagnosis, operating surgeons as well as the time between discectomy and control examination were collected from the medical records (Take Care, CGM) at the section of Oral diagnostics and surgery. The clinical diagnosis was registered as DDwR, DDwoR, systemic arthritis (SA) including rheumatoid and psoriatic arthritis involving the TMJ, and hypermobility/repeated mandibular dislocation.

2.4.2 | Predictor variable: Radiographic features

Radiographic findings were registered by adopting a modified Ahmad classification (Ahmad et al., 2009). Presence and location of erosion, bone apposition, flattening of joint surface, subchondral pseudocyst and medullar sclerosis were registered for temporal joint component and mandibular condyle, respectively. The presence of the above-mentioned findings was registered as a dichotomic yes/no answer while the locations of radiographic signs were defined as the medial, lateral and combined medial and lateral part of TMJ components. We defined condyle position in the fossa as anteriorly, centrally, posteriorly situated on axial corrected sagittal views. Furthermore, the presence of joint mice, that is radiopaque loose bodies within the joint, and the minimum joint space expressed in millimetres were recorded.

In order to verify the reliability of radiographic assessment in terms of inter-observer agreement, 15 CBCT volumes corresponding to 21% of the image material were randomly selected and reassessed by the examiners WM and DB.

2.4.3 | Outcomes variables

Postoperative parameters related to pain estimated with visual analogue scale (VAS) and maximal interincisal opening measurement were assessed to evaluate the subjective and objective outcome of the surgery, respectively. VAS is a scale used to determine pain levels experienced by individuals with 0 signifying no pain and 10 the worst pain ever.

In the present study, success was defined as a VAS improvement of at least 40% or a score of less than 4, and an interincisal opening of 35 mm or more (Holmlund et al., 2013). As a failure of the subjective parameter is not necessarily associated with a failure of its objective counterpart, or vice versa, success for each of the parameters was evaluated separately. Moreover, a third parameter, named the combined outcome, was included. In this regard, success was defined as when both the subjective and objective parameters indicated treatment success and failure when at least one of these parameters indicated treatment failure. For the eleven bilateral cases, if a failure was registered on at least one side, both joints were considered failure in the analysis of the objective and combined outcomes. The rationale is that if one of the sides restricts the interincisal opening, the negative objective outcome will also be reflected for the other side, even though no pathology may exist.

2.5 | Statistical analyses

S-Plus 8.0 (TIBCO Software Inc) was used for the statistical analyses. The following values were calculated for the variables, when applicable: average, standard deviation, minimum, maximum, percentage and odds ratio. Univariate relations between predictor variables and the treatment outcome were assessed by means of Fisher exact test for categorical variables and a generalized linear model for binary outcomes using a logit link for the continuous data. Furthermore, univariate logistic regression was applied to analyse each response variable separately on the probability of successful treatment outcomes before setting up a possible multivariate analysis model.

p-values less than 0.05 were regarded as significant. Fleiss' Kappa determined the intra- and inter-rater agreements.

3 | RESULTS

3.1 | General outcomes

A total number of 62 eligible study samples, 51 unilateral and 11 bilateral. The clinical diagnosis distribution was 40 with DDwR, 13 with DDwoR, six with SA and three with hypermobility/luxation. Gender distribution was 51 females and 11 males (4.6:1) with age ranging from 17 to 69 (Table 1).

The age group of ≥20;<35 had the lowest success rate compared to the other three groups. The success rate seemed to be comparable among these other three age groups with a slight tendency to increase as the age increases. The combined successful outcome was 76.7% for females and 69.2% for men. The various age groups in relation to the distribution of gender, number of uni- and bilateral surgeries and successful rates are shown in Table 1.

The average age for the combined success cases was 38.4 years (sd = 15.1) and for the failed combined cases, 31.7 years (sd = 11.8). The average minimum joint space was 1.0 mm (sd = 0.6) for combined successful outcomes and 0.7 mm (sd = 0.6) for the failed ones. Statistically significant difference was only found in the time interval of the check-up appointments after surgery, being 8 months (sd=4.3) for the combined success cases and 11.9 months (sd = 13.2) for the failed ones ($p < 0.05$). However, two of the subjects stood out from the rest of the group, due to relatively extended intervals. When excluding the mentioned subjects, the correlation proved to be insignificant ($p = 0.65$). Table 2 illustrates the mean and standard deviation (SD) of the three continuous variables in relations to the outcomes.

There was a significant negative association between bone apposition on the temporal component and successful objective as well as combined outcomes. The presence of a subchondral pseudocyst on the mandibular condyle associated significantly with the unsuccessful subjective outcome. Also, medullar sclerosis presented on the condyles associated statistically significant with both objective and combined outcomes. None of the other radiographic signs demonstrated significant association with the outcome of discectomy (Table 3). Table 3 also displays the *p*-values of Fisher exact tests and odds ratios for the categorical variables demonstrating the associations between radiographic and clinical variables on one hand and subjective, objective and combined outcomes on the other hand. For the none-binary predictors, odds ratios were calculated between all possible combinations and thus summarized as a range.

None of the clinical categorical variables, that is gender, side of the affected TMJ, clinical diagnosis, operating surgeons, had a significant association with surgical outcomes expect for the clinical diagnosis (Table 3). The success rates in association with the diagnoses are displayed in Table 4. The combined results were the highest for

TABLE 1 Demographics in terms of age, gender, number of surgeries and success rate

Age at pre-surgical radiographic examination				Gender		# of surgeries		Success		
				% (n)		% (n)		% (n*)		
Age groups	% (n)	Median	SD	Female	Male	1	2	Sub	Obj	Com
0;<20	14.5 (9)	18	1.6	88.9 (8)	11.1 (1)	77.8 (7)	22.2 (2)	83.3 (10)	75.0 (9)	66.7 (8)
≥20;<35	29 (18)	28	4.3	89.9 (16)	11.1 (2)	72.2 (13)	27.8 (5)	69.6 (16)	73.9 (17)	65.2 (15)
≥35;<50	30.6 (19)	43	4.3	73.7 (14)	26.3 (5)	84.2 (16)	15.8 (3)	85.7 (18)	85.7 (18)	85.7 (18)
≥50;<70	25.8 (16)	55	6.0	81.3 (13)	18.7 (3)	93.8 (15)	6.2 (1)	94.4 (17)	88.9 (16)	83.3 (15)

Abbreviations: Com, combined outcome; Obj, objective outcome; Sub, subjective outcome.

*There were 62 patients, of which 11 had bilateral discectomies, which resulted in a total of 73 joints.

TABLE 2 Descriptive statistics are listed for subjective, objective and combined outcomes associated to continuous variables of radiographic and clinical related features including joint space, age (years) at CBCT exposure and the duration interval between surgery and check-up appointment

	Subjective outcome Success rate: 82%		Objective outcome Success rate: 81%		Combined outcome Success rate: 75%	
	Success	Failure	Success	Failure	Success	Failure
Variables	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Joint space (mm)	0.96 (0.59)	0.71 (0.61)	0.97 (0.6)	0.69 (0.57)	0.98 (0.6)	0.72 (0.56)
Age	37.7 (15.0)	32.1 (11.6)	37.8 (15.0)	32.2 (12.2)	38.4 (15.1)	31.7 (11.8)
Time (months)	7.8 (4.26)	14.2 (14.9)	8.7 (6.5)	10.0 (11.4)	8.0 (4.3)*	11.9 (13.2)*

*indicates $p < 0.05$ according to generalized linear model for binary outcomes using a logit link.

TABLE 3 Odds ratios and P-values calculated by Fisher's exact test are listed for the 73 joints for subjective, objective and combined outcomes associated to non-parametric variables of radiographic and clinical-related features

	Subjective outcome Success rate: 82%				Objective outcome Success rate: 81%				Combined outcome Success rate: 75%			
	TJC		MC		TJC		MC		TJC		MC	
Radiological features	**OR**	**Fisher exact (P)**	**OR**	**Fisher exact (P)**	**OR**	**Fisher exact (P)**	**OR**	**Fisher exact (P)**	**OR**	**Fisher exact (P)**	**OR**	**Fisher exact (P)**
Erosion	0.00–1.779	0.442	0.81–2.471	0.694	0.00–3.455	0.103	0.333–9	0.092	0.00–1.967	0.189	0.333–4.714	0.292
Bone apposition	0.00–4.879	0.074	0.395–4.222	0.237	**0.00–9.4**	**0.001**	1.583–2.608	0.230	**0.00–6.875**	**0.004**	0.75–3	0.270
Flattening	0.429–2.1	0.850	0.7–3.875	0.230	1–4.875	0.097	1.55–3.875	0.122	1–3.875	0.208	1.176–2.417	0.157
Medullar sclerosis	0.4–3.524	0.387	0.00–2.5	0.421	**0.875–5.2**	**0.041**	**0.00–11.2**	**0.011**	0.389–6.75	0.061	**0.00–7.429**	**0.030**
Subchondral pseudocyst	-	-	**8.444**	**0.017**	-	-	3.75	0.124	-	-	4.952	0.058
Condyle position	OR: 0.16–1.846		P value: 0.156		OR:0.448–0.569		P value: 0.293		OR: 0.202–0.593		P value: 0.188	

	Subjective outcome Success rate: 82%		Objective outcome Success rate: 81%		Combined outcome Success rate: 75%	
Clinical related features	**OR**	**Fisher exact test (*p*)**	**OR**	**Fisher exact test (*p*)**	**OR**	**Fisher exact test (*p*)**
Affected side	0.98	1	1.692	0.552	1.2	0.790
Operators	0.952–1.286	1	0.311–3.333	0.579	0.915–1.7	0.957
Gender	1.5	0.690	2.222	0.258	1.46	0.723
Diagnosis	0.88–3.03	0.237	**0.08–25.9**	**0.003**	**0.07–11.01**	**0.016**

Abbreviations: TJC, temporal joint component; MC, mandibular component, OR, Odds ratio.

The exact *P* values are in the next columns, displayed in bold.

TABLE 4 Combined outcome related to the diagnoses

Diagnosis	Successful outcome (n)	Failed outcome (n)	Total (n)	Success (%)
DDwR	39	7	46	84.8
DDwoR	9	7	16	56.2
SA	3	4	7	42.9
Hypermobility/Luxation	4	0	4	100

Note: *p*-value Fisher exact test: 0.0157.

Abbreviation: DDwR, disc displacement with reduction; DDwoR, disc displacement without reduction; SA, systemic arthritis involving the TMJ.

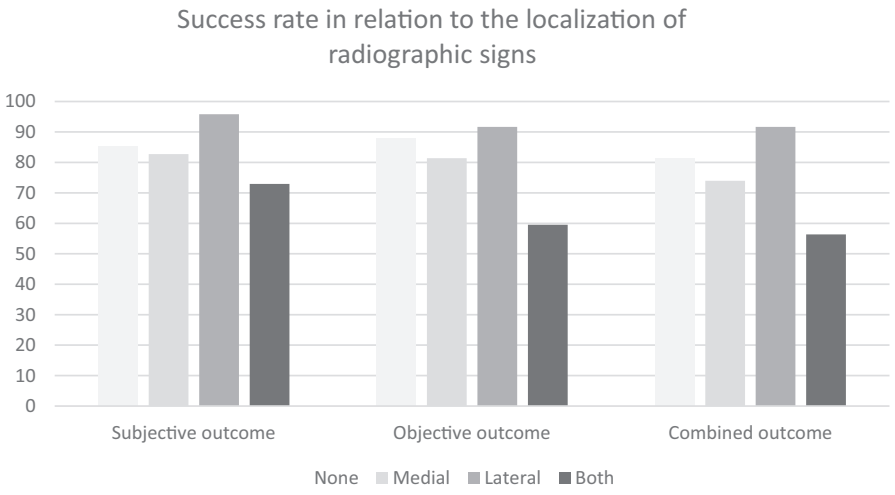

FIGURE 2 The success rates defined by subjective, objective and combined outcomes are illustrated in relation to the locations of all registered radiographic signs

hypermobility/repeated mandibular dislocation (100%) and DDwR (84.8%), whereas they were the lowest SA (42.9%) and DDwoR (56.2%).

Figure 2 shows the success rates defined by subjective, objective and combined outcomes in relation to locations of the registered radiographic signs. In general, the success rates decreased when radiographic findings were noticed on both medial and lateral parts of the TMJ joints.

The intra- and inter-rater agreement were good for all the radiographic variables ranging from 0.75 to 1 except for erosion on the temporal joint component where the inter-rater agreement is 0.52 (supplementary material). In addition, the rater agreements of the joint mice variable were unreliable, since the dentist did not detect any joint mice in the set of 20 randomized subjects, whereas the specialist registered one case.

3.2 | Predictors of outcome failure

Odds ratios of all predictors on association with treatment outcomes may be found in Table 2. Univariate logistic regression analyses demonstrated that two radiographic variables, that is subchondral pseudocyst of the mandibular condyle and bone apposition on the temporal part of TMJ and one clinical variable, that is the diagnosis DDwR–SA may be used to predict the outcomes of discectomy (Table 5). The successful subjective outcome after discectomy in the absence of subchondral pseudocysts had an odds ratio of 5.2 (p = 0.04). The odds ratios between different diagnoses show that subjects afflicted with painful clicking had 25.9 times higher odds to have a successful objective outcome after discectomy compared to those having arthritis (p = 0.03). If there was a bone apposition located medially and laterally and/or centrally in the temporal joint component, the odds ratio was 9.3 for an objective failure versus not having any bone apposition in that region (p = 0.04).

Diagnosis was the only variable that showed a significant association with the combined outcome after discectomy. More specifically, the difference between painful clicking and arthritis. Subjects diagnosed with painful clicking had 11 times higher odds success rate than those with arthritis (p = 0.03) (Table 5).

4 | DISCUSSION

Surgical removal of the disc of TMJ, discectomy, is recognized as an effective treatment of persistent pain and limitation of mouth opening for patients who do not respond to conservative treatment. Discectomy is only relevant to consider in cases where the disc is considered the cause of the TMJ condition. The methods have shown good outcome in studies of both patients with DDwR and DDwoR (Bjørnland and Larheim, 2003; Miloro and Henriksen, 2010). Drawbacks are a postsurgical anatomical adaption sometimes developing into osteoarthritis. Surgical alternatives that are

TABLE 5 Significant associations with successful treatment outcomes were found in three predicted variables listed in terms of Odds-ratio and *p*-values

	Variables	Details	Odds ratio	*p*-value
Subjective outcome	Subchondral pseudocyst (mandibular condyle)	No presence-presence	**5.15**	**0.04**
Objective outcome	Diagnosis	DDwR-DDwoR	6.90	0.13
		DDwR-SA	**25.90**	**0.03**
		DDwR-Hypermob	2.13	0.98
		DDwoR-SA	3.75	0.72
		DDwoR-Hypermob	0.31	0.95
		SA-Hypermob	0.08	0.70
	Bone apposition on the temporal part of TMJ	No-Medial	10.86	0.91
		No-Lateral	0.04	0.68
		No-Medial & lateral	**9.25**	**0.04**
		Medial-Lateral	0.004	0.65
		Medial-Medial & lateral	0.85	0.99
		Lateral-Medial.& lateral	242.9	0.26
Combined outcome	Diagnosis	DDwR-DDwoR	4.80	0.10
		DDwR-SA	**11.01**	**0.03**
		DDwR-Hypermob	0.74	1.00
		DDwoR-SA	2.30	0.83
		DDwoR-Hypermob	0.15	0.79
		SA-Hypermob	0.07	0.57

Abbreviations: DDwoR, disc displacement without reduction; DDwR, disc displacement with reduction; Hypermob, joint hypermobility including mandibular dislocation/luxation; SA, systemic arthritis.

The exact *P* values are in the next columns, displayed in bold.

discpreserving are discopexy or discoplasty (Renapurkar, 2018). However, the choice of treatment remains a debated issue and there is an urgent need for large-scale randomized trials for comparison. Operations to remove a damaged intra-articular disc in arthritis patients only occur when symptoms progress despite conservative measures, pharmacological intervention, arthroscopy and arthrocentesis (O'Connor et al., 2017).

Although the success rate of discectomies is relatively high, a considerable portion of the patients that undergo this surgical procedure does not experience significant improvements. Twenty-five percent of the discectomies in this study were classified as unsuccessful, which was consistent with the previous reports (Eriksson and Westesson, 1992, 2001; Holmlund and Axelsson, 1990; Holmlund et al., 1993, 2013; Molt et al., 2019; Nyberg et al., 2004). However, when comparing earlier studies it should be kept in mind that heterogeneity in low number patient populations and variability in the selection of non-randomized design may influence the results.

Clinical features in terms of gender and operators had comparable success rate between successful and unsuccessful groups whereas the outcome of the age analysis showed that the age group of ≥20;<35 had the lowest success rate as compared to the other three groups (see Table 1). However, when analysing age as a predictor for the surgical outcome, no statistically significant difference could be found (Table 3). Furthermore, success is relative to the burden of symptoms prior to surgery and to the patients' coping abilities as well as commitment to the recommended conservative components of the treatment. It is therefore hard stating a certain cutoff for success. Yet, prior to the clinical study, minimal outcome criteria for a successful result have been defined (Holmlund et al., 2013).

There was a tendency that patients with diagnoses of DDwoR had a higher risk of surgery failure compared with diagnoses of DDwR (odds ratio 4.8, $p = 0.1$, Table 5), which was similar to a previous study in which significant differences between patients with reciprocal clicking and chronic closed lock were found only as far as pain was concerned (Holmlund et al., 2013). On the other hand, clicking sounds do not necessarily correlate with pain severity or functional treatment (Okeson & de Kanter, 1996). There were seven TMJs with the diagnosis SA in the study sample of which four of them were classified as unsuccessful. All these patients were diagnosed by a specialist in rheumatology and the complaints from the TMJ were considered part of the systemic disease. A statistically significant difference with an odds-ratio of 11 was found between the two diagnoses of DDwR and SA. The correlation was more than double for the objective outcome. Consequently, it can be concluded that a SA seems to have a poor prognosis if discectomy is performed.

As depicted by the intra- and inter-rater agreement coefficients (supplementary document), the reliability results were good. The

only exception was the inter-rater agreement for erosion in the temporal joint component (0.52). This was not unexpected, as small erosions are challenging to detect considering possible artefacts in CBCT images (Alkhader et al., 2010).

This study's findings have to be seen in light of some limitations, of which some are related to the disadvantage of a retrospective cohort study design, such as the diagnosis of the systemic arthritis relied solely on the history of patients. Another limitation with the study is the diagnoses of DDwR and DDwoR. The diagnoses of disc displacements is a matter of debate where the diagnostic criterion available today has their own inherent advantages and disadvantages. The clinical features that were used for diagnoses in the current study were based on patient history and findings during clinical examination (Lund et al., 2020). CBCT was applied as for the pre-surgical assessment to orientate the operators with morphology and possible abnormality of osseous joint components. Although the study aimed to evaluate if preoperative hard tissue findings on CBCT can predict the outcome of discectomy, a limitation of the present study is the lack of soft tissue diagnostics found in MRI. Preferentially, CBCT shall be validated and compared with MRI in future studies for pre-discectomy examination since the influence of soft tissue visualization on the choice of treatment and treatment outcome is of high clinical relevance. Unquestionably, as compared to the MR technique, ionizing radiation is of critical concern when CBCT is applied (SEDENTEXTCT, 2012). Optimization of examination protocol is an effective approach in minimizing radiation dosage (Iskanderani et al., 2020; Kadesjö et al., 2015).

To our knowledge, there are no articles that have probed pre-surgical radiographic features in relation to the outcome of discectomies of TMJ. A statistically significant relationship was detected regarding the absence versus the presence of a subchondral pseudocyst for the subjective outcome, odds-ratio of 5.2. Since the intra- and interrater agreements coefficients were 1, the probability of this variable being a predictor was further enhanced. Furthermore, an odds-ratio of 9.3 for the objective outcome was found, related to no sign of bone apposition versus bone apposition seen on both medial and lateral aspect of temporal joint component. Also in this case, the inter-rater coefficient was 1. This might imply that an extensive apposition can potentially restrict the movements of the TMJ. These putative predictive features differ from the anatomical adaptation changes described postoperatively after discectomy.

In conclusion, this pioneering study has verified three potential predictors associated with unsuccessful outcomes of discectomy such as the clinical diagnosis of SA and radiographic findings related to bone apposition and subchondral pseudocysts using CBCT. More studies, preferably with a higher number of subjects, would be required to confirm the predictive value of the presently proposed variables in relation to the outcome of discectomies, especially in SA patients.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHOR CONTRIBUTIONS

William Minston: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Software; Validation; Visualization; Writing-original draft; Writing-review & editing. **Daniel Benchimol:** Conceptualization; Data curation; Formal analysis; Investigation; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing-original draft; Writing-review & editing. **Reinhilde Jacobs:** Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Supervision; Validation; Visualization; Writing-original draft; Writing-review & editing. **Bodil Lund:** Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Resources; Supervision; Validation; Visualization; Writing-original draft; Writing-review & editing. **Carina Kruger Weiner:** Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Resources; Supervision; Validation; Visualization; Writing-original draft; Writing-review & editing. **Wim Coucke:** Conceptualization; Data curation; Formal analysis; Methodology; Project administration; Software; Validation; Writing-original draft; Writing-review & editing. **Xie Qi Shi:** Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing-original draft; Writing-review & editing.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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