Original Article

PRESSURE-CONTROLLED AUTOMATED ARTHROCENTESIS FOR TMJ INTERNAL DERANGEMENT: A PROSPECTIVE CLINICAL TRIAL DEMONSTRATING IMPROVED FUNCTIONAL RECOVERY

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ABSTRACT

The aim of the study is to evaluate the clinical effectiveness of automated irrigation arthrocentesis in TMJ internal derangement compared to syringe-based lavage, which is limited by fluctuating hydraulic pressure and operator fatigue. This prospective clinical trial included 10 patients with clinically and radiographically diagnosed TMJ. Internal derangement unresponsive to >3 months of conservative therapy. Arthrocentesis was performed using Nitzan's two-needle technique with 150 ml of saline at 40 kpa via a dental implant motor. Pain, maximum mouth opening, lateral movement, and clicking were assessed preoperatively, immediately postoperatively, and at the 1st and 3rd months. Data were analysed using 100 Wilcoxon signed-rank tests ($P < 0.05$). All 10 patients completed follow-up. The Friedman test showed significant improvement across parameters over time ($P < 0.001$). Mean VAS scores decreased from 7.30 ± 0.95 preoperatively to 0.70 ± 0.95 at 3 months. Maximal mouth opening increased from 24.60 ± 1.43 mm pre-operatively to 39 ± 0.67 at 3 months. Maximal lateral movement showed a similar significant increase from 24.60 ± 1.43mm pre-operatively to 39.00 ± 0.66 at 3 months. Cochran's Q test showed significant reduction in clicking ($Q = 13.957$, $P=0.003$), decreasing from 8 patients pre-operatively to 1 patient at 3 months. The McNemar test was significant between preoperative and 3-month assessments only ($P=0.016$). Pressure-controlled Automated arthrocentesis is a safe, minimally invasive, cost-effective outpatient technique for TMJ internal derangement. Consistent lavage pressure improves functional recovery requiring specialized arthroscopic equipment. It may serve as a reliable intermediate option before open joint surgery.

Key words: Arthrocentesis, Automated irrigation, Internal derangement, Lavage, Maximal mouth opening, Temporomandibular joint.

Introduction

The temporomandibular joint (TMJ) is a complex synovial articulation responsible for coordinated mandibular movements essential for mastication, speech, and deglutition. Owing to its delicate anatomical relationships and continuous functional loading, the joint is vulnerable to a range of musculoskeletal and functional disorders collectively termed temporomandibular disorders (TMDs) [1, 2]. Internal derangement, characterized by a disturbed disc–condyle relationship, is among the most frequent clinical entities encountered [1].

Common clinical features include pain, limited mouth opening, mandibular deviation on opening, and audible joint sounds such as clicking or crepitus leading to significant functional impairment [1, 3]. Although most individuals respond well to conservative measures, including parafunctional habit control, occlusal splints, analgesics, physiotherapy, and third-molar removal when indicated, approximately 5% remain symptomatic [2].

Arthrocentesis was introduced by Nitzan *et al*. in 1991 and provides therapeutic benefit by distending the superior joint space, lysing adhesions, and flushing inflammatory mediators such as IL-1β, TNF-α, and prostaglandin E_2 [3-5]. Conventional syringe-based arthrocentesis is effective but limited by inconsistent irrigation pressure, restricted lavage volume, and operator fatigue [6, 7]. Automated irrigation systems address these limitations by delivering continuous, controlled saline flow at physiologic pressures (up to 40 kPa), ensuring uniform lavage, smoother joint distension, and greater patient comfort [8, 9]. These systems typically deliver 150–300 mL of irrigant within 2–3 minutes, promoting efficient removal of inflammatory byproducts, reducing operative time, and enhancing procedural predictability [9, 10].

The present aimed study was to evaluate the clinical effectiveness of automated irrigation arthrocentesis in patients with TMJ internal derangement unresponsive to conservative management [11-20]. The specific objectives were to assess its impact on pain intensity, maximal mouth opening, lateral mandibular movements, and the presence of joint sounds [21-24].

Materials and Methods

Study design

This prospective clinical trial was conducted after obtaining approval from the Institutional Review Board of Sree Balaji Dental College and Hospital and the Institutional Ethics Committee (IEC No.: SBDCH-IEC-CT-/11-04/11). All procedures adhered to the Declaration of Helsinki guidelines [2].

Patient selection

The study included a total of 10 patients diagnosed with temporomandibular joint (TMJ) internal derangement [1, 3]. The study protocol was explained to all the patients, and written informed consent was obtained before the procedure and subsequent follow-up [2].

Inclusion and exclusion criteria

Patients aged 20-55 years with clinically and radiologically confirmed TMJ internal derangement characterized by disc displacement, pain on mouth opening, crepitus, deviation of the mandible, and restricted mouth opening (<35 mm) and who showed no improvement after at least three months of conservative management were included [1, 3, 21, 23]. Exclusion criteria included systemic disease, coagulation disorders, past TMJ surgery or fractures, joint infections, inflammatory arthropathies, and pathological causes of trismus, including oral submucous fibrosis or impacted third molars [23, 24].

Sample size

The sample size was estimated using G*Power software with an effect size $f = 0.5$, an alpha error probability (α) of 0.05 and a desired power (1 – β error probability) of 0.95. The design involved one group and four repeated measurements. The analysis resulted in a total required sample size of 10 participants to achieve the specified power with an actual power of approximately 95.1%.

Armamentarium

The surgical setup comprised standard diagnostic instruments (mouth mirror, explorer, and tweezer), povidone-iodine solution, 2 mL and 20 mL syringes, 18G and 21G needles, a Vernier caliper, a metal scale, a skin marker, 2% lidocaine with 1:200,000 adrenaline, and 0.9% normal saline. A physiodispenser with irrigation tubing was used to facilitate automated saline delivery during the procedure.

Parameters and assessment scales

Clinical parameters

All patients were thoroughly evaluated for signs and symptoms related to TMJ internal derangement, specifically pain, mouth opening, clicking, crepitus, and lateral mandibular movement objectively by Investigator 1. The various clinical parameters assessed were pain, mouth opening, joint clicking, and lateral mandibular movement [25-30]. These were assessed in the pre-operative as well as the post-operative period. Pain was assessed by using a visual analog scale (VAS). Maximal mouth opening (MMO) was measured as the inter-incisal distance in millimeters by using a vernier caliper. Lateral mandibular movement was determined by calculating the mean of right and left excursions measured in centimeters. Lateral mandibular movement was assessed clinically by measuring the maximum right and left lateral excursions from the maxillary midline using a millimeter scale. The mean of both excursions was calculated to minimize side-specific variability and obtain a representative lateral movement value. The presence or absence of joint clicking was evaluated through palpation and auscultation of the temporomandibular joint during mandibular movements.

TMJ internal derangement was assessed using standardized tomographic imaging obtained preoperatively in both closed and open-mouth positions. A single calibrated observer (Investigator 1) evaluated the tomograms for condylar morphology, superior and posterior joint-space dimensions, and condylar position relative to the articular eminence. The degree of anterior translation was determined by assessing the condyle's ability to traverse the apex of the eminence during mouth opening. Restriction in condylar translation, asymmetry in joint-space dimensions, or morphological alterations corresponding to clinical symptoms were considered diagnostic indicators of internal derangement.

Surgical technique

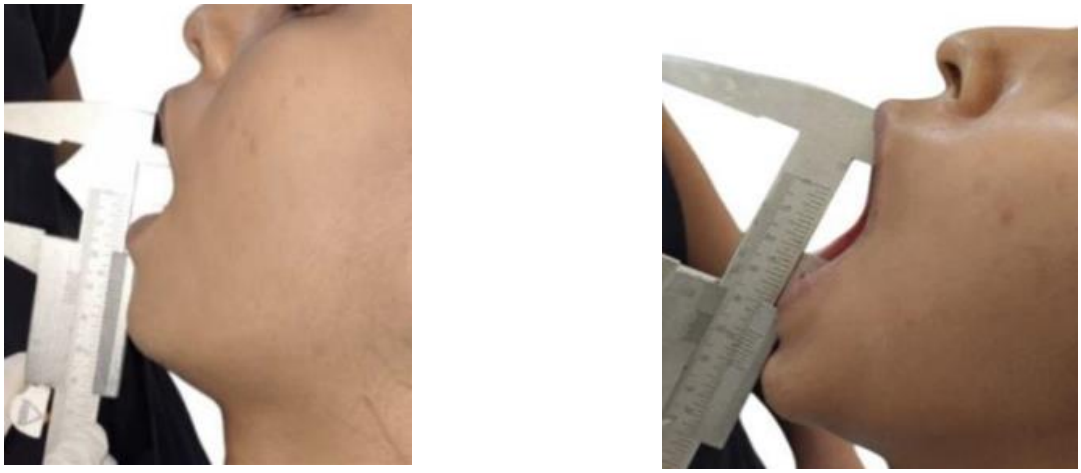
A standardized surgical procedure was followed by a single operating surgeon (Investigator 2) for all patients. The preauricular region was aseptically prepared using povidone–iodine solution, and the external auditory canal was protected with cotton to prevent saline entry. Local anesthesia was administered via an auriculotemporal nerve block using 2% lidocaine with 1:200,000 adrenaline. Arthrocentesis was performed according to Nitzan's two-needle technique with entry points marked along the canthotragal line **(Figure 1).** The first point was positioned 10 mm anterior to the tragus and 0.5 mm inferior to the line, while the second point was marked 20 mm anterior to the tragus and 1 mm inferior to the line. A 21-G needle was inserted into the superior joint compartment at the first (posterior) point, and joint distension was initiated with 5 mL of saline. A second 21-G needle was then placed at the anterior point to establish outflow. The irrigation tubing of the physiodispenser was connected to the anterior needle, delivering 150 ml of sterile saline at 40 kPa pressure over approximately two minutes. Lavage was followed by gentle mandibular manipulation to enhance disc translation and joint mobility.

a) b) c)

Figure 1. Nitzans two needle technique entry points marked

Postoperative management protocol

Patients received amoxicillin–clavulanate (500/125 mg) twice daily for 5 days and diclofenac–paracetamol as needed. Patients were instructed to follow a soft diet for one week and to restrict mouth opening to less than 20 mm during the initial healing phase. From the second postoperative week onward, gradual mouth-opening and lateral mandibular exercises were performed daily under visual guidance using a mirror to improve joint mobility and reduce the risk of adhesion formation.



a) b)

Figure 2. a) Pre operative mouth opening, b) Post operative mouth opening

Review protocol

Parameters such as pain, maximal mouth opening **(Figure 2),** lateral movement, joint clicking sound, and TMJ tomogram were evaluated in the preoperative period as well as in the immediate postoperative, 1st, and 3rd postoperative months by investigator 3.

Statistical analysis

The data was analyzed using SPSS software version 26.0 by IBM Corp. The Shapiro-Wilk test was used to determine its normal distribution. Because the data was not normally distributed, the non-parametric Friedman test was employed to compare differences in the Visual Analog Scale, maximal mouth opening, and maximal lateral movement throughout four time periods: pre-op, immediate post-op, post-op 1st month, and post-op third month. The Cochrane Q test was used to determine the significance of binary data (present or missing) on clicking sounds throughout four different time periods: pre-op, immediate post-op, post-op first month, and post-op third month. A P value of <0.05* was judged statistically significant.

Results and Discussion

Ten patients completed all follow-up evaluations. Non-parametric analysis using the Friedman test demonstrated statistically significant improvements across all assessed parameters over time ($p < 0.001$), consistent with previously

reported outcomes of temporomandibular joint arthrocentesis [3, 4, 6, 8, 9]. Mean Visual Analogue Scale scores (**Figure 3**) decreased progressively from 7.30 ± 0.95 preoperatively to 4.80 ± 0.79 immediately postoperatively, 2.50 ± 0.71 at 1 month, and 0.70 ± 0.95 at 3 months **(Table 1, Figure 4),** indicating sustained pain reduction [3, 4, 21, 24]. Maximal mouth opening increased from a pre-operative mean of 24.60 ± 1.43 mm to 31.90 ± 1.29 mm immediately post-operatively, 35.20 ± 1.03 mm at 1 month, and 39.00 ± 0.67 mm at 3 months, demonstrating progressive functional improvement comparable to earlier reports [7, 10, 23, 31, 32]. Similarly, maximal lateral mandibular movement **(Figure 5)** improved significantly from 24.60 ± 1.43 mm preoperatively to 39.00 ± 0.66 mm at 3 months, reflecting restoration of lateral mandibular function [1, 2, 33]. Analysis of joint clicking using Cochran's Q test showed a significant reduction over time ($Q = 13.957$, $p = 0.003$), with clicking decreasing from 8 patients preoperatively to 1 patient at 3 months **(Figure 6);** the McNemar test revealed a statistically significant reduction only between pre-operative and 3-month assessments ($p = 0.016$), indicating a time-dependent resolution of joint sounds following intervention [31-34].

Table 1. Descriptive Statistics and Friedman Test Results for Maximal Mouth Opening (MMO) Across Pre- and Post-Operative Time Points

	Descriptive Statistics					Mean Rank	P value
	N	Mean	Std. Deviation	Minimum	Maximum		
PRE OP	10	24.60	1.430	22	27	1.00	**0.000***
IMMEDIATE POST OP	10	31.90	1.287	30	34	2.00	
POST OP 1 MONTH	10	35.20	1.033	34	37	3.00	
POST OP 3 MONTH	**10**	**39.00**	**.667**	**38**	**40**	**4.00**	

Internal derangement of the TMJ continues to be a frequent cause of pain and restricted jaw function in clinical practice [1, 2]. The underlying problem usually involves a disturbed disc-condyle relationship along with synovial inflammation and increased intra-articular friction [1, 3]. As the condition progresses, adhesions, and inflammatory mediators accumulate within the superior joint space, further limiting movement [4, 5]. Arthrocentesis works by physically expanding the joint space, breaking down any adhesions and washing out inflammatory debris [3, 4]. This helps the disc move more freely, reduces friction within the joint, and alleviates pain, making it a reliable option for patients who do not respond to conservative treatment [7, 24].

Since Nitzan and colleagues first described it, the technique has been steadily refined [3, 4]. Early studies by Murakami *et al*. and later by Yura and Totsuka showed high success rates and highlighted the importance of adequate hydraulic pressure to effectively break adhesions [6, 8]. More recent modifications by Alkan and Kilic introduced automated irrigation units capable of maintaining constant pressure, which improves the consistency of lavage and reduces the variability associated with manual syringe irrigation [9].

The results of the present study are in line with these earlier reports [6, 8, 9]. Patients showed a clear improvement in pain, mouth opening, lateral movements, and joint sounds immediately after the procedure, with steady progress over the three-month follow-up [21-23]. Similar outcomes have been documented by Neeli *et al*. and Kuruvilla and Prasad using the conventional syringe technique [22, 23]. Despite using a smaller irrigation volume, the present study achieved comparable results, supporting the view put forward by Kaneyama *et al*. that sustained hydraulic pressure is more critical than the absolute volume of fluid used [10].

Although the study was not designed to evaluate biochemical markers, the rapid reduction in symptoms fits well with previous work by Guarda-Nardini and by Emshoff and Rudisch, who demonstrated reductions in inflammatory cytokines following lavage [21, 34]. The clinical improvements observed here likely reflect similar intra-articular changes [5].

From a technical standpoint, automated irrigation offered several advantages [9, 35]. Maintaining a constant pressure of around 40 kPa ensured predictable joint distension and more efficient lavage compared with manual syringe irrigation, which is often limited by fluctuating pressure and operator fatigue [8, 9]. Similar observations have been reported by Gudova and by Grossmann [35, 36]. An additional practical advantage in this study was the use of a standard dental implant motor, allowing the technique to be easily adopted without requiring specialized arthroscopic equipment [9].

No intraoperative or postoperative complications were encountered. This is consistent with the well-established safety profile of arthrocentesis reported by Smith and Soni *et al*. [2, 37]. The procedure was well tolerated under local anesthesia, and its simplicity makes it suitable for routine outpatient practice [2, 7]. Although various adjunct intra-articular agents have been proposed, the consistent improvements in this study suggest that pressure-controlled lavage alone is sufficient to achieve meaningful clinical benefit [24, 34].

In conclusion, the results of this study support the use of arthrocentesis, particularly with automated, pressure-controlled irrigation, as a dependable, safe, and minimally invasive treatment for TMJ internal derangement [8, 9, 24]. The ability to maintain consistent hydraulic pressure appears to improve lavage effectiveness, reduce operator variability, and give predictable improvements in pain and function [8, 10]. These benefits make automated arthrocentesis a practical improvement on the conventional approach and a desirable choice in modern TMJ care [24].

Advantages of the study

Automated irrigation arthrocentesis allows efficient removal of inflammatory mediators through controlled hydraulic pressure, ensuring consistent joint lavage [8, 9]. The technique reduces operator fatigue, standardizes the procedure, and can be easily performed using standard dental implant motors [9]. Its simplicity and cost-effectiveness make it suitable for routine outpatient practice without the need for specialized arthroscopic equipment [2].

Clinical implications of the study

Automated irrigation arthrocentesis is an effective intermediate treatment for patients unresponsive to conservative therapy [7, 24]. Significant functional and symptomatic improvements can be achieved without adjunct intra-articular medications, potentially reducing the need for more invasive interventions [24, 34].

Limitations of the study

The limitations of the present study include the small sample size and lack of MRI correlation, which could have provided deeper insight into structural and inflammatory changes [24, 32]. Long-term multicentric studies are recommended to assess the longevity of results and recurrence rates [31].

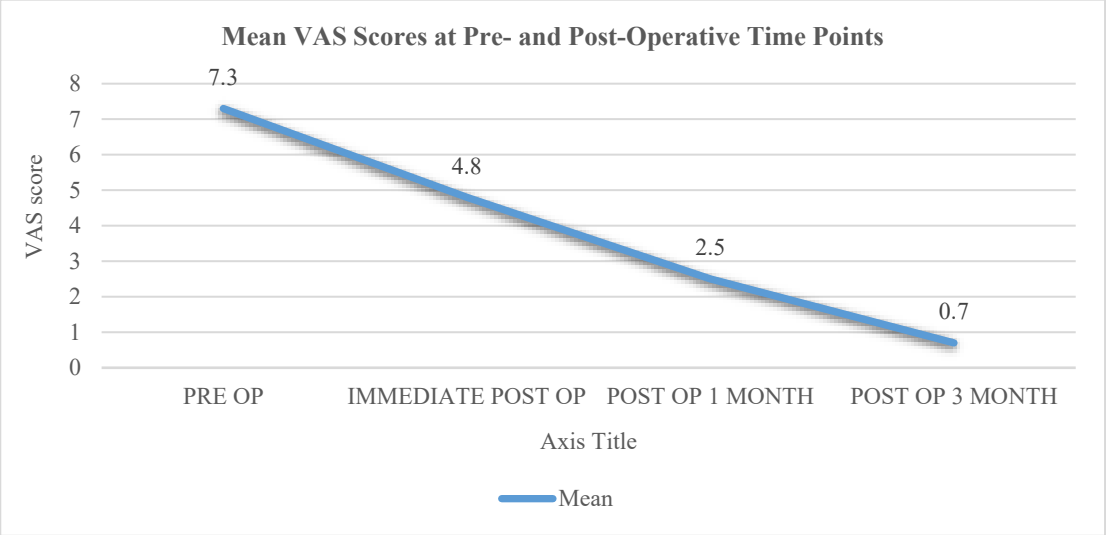


Figure 3. Line Figure showing VAS Scores at Pre- and Post-Operative Time Points

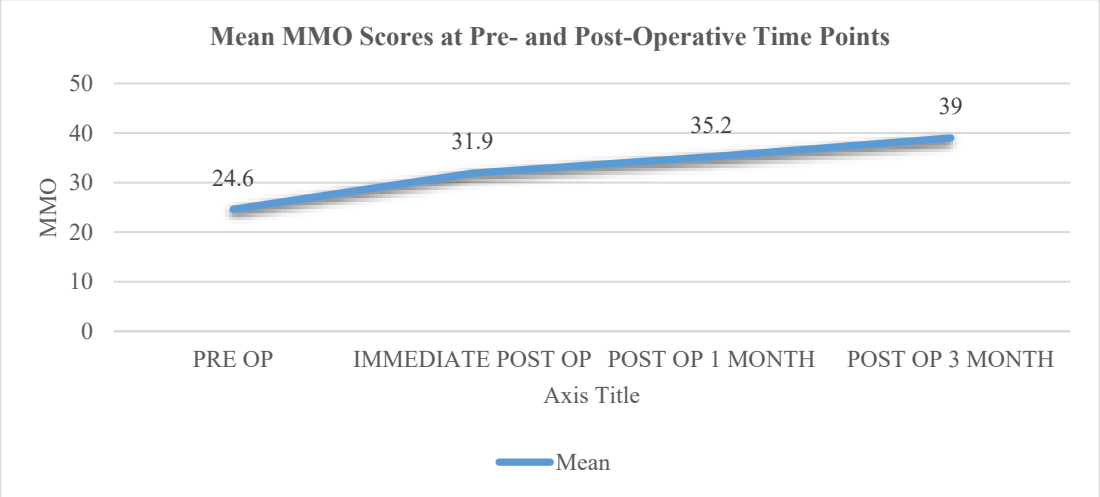


Figure 4. Line Figure showing Maximal Mouth Opening (MMO) scores Across Pre- and Post-Operative Time Points

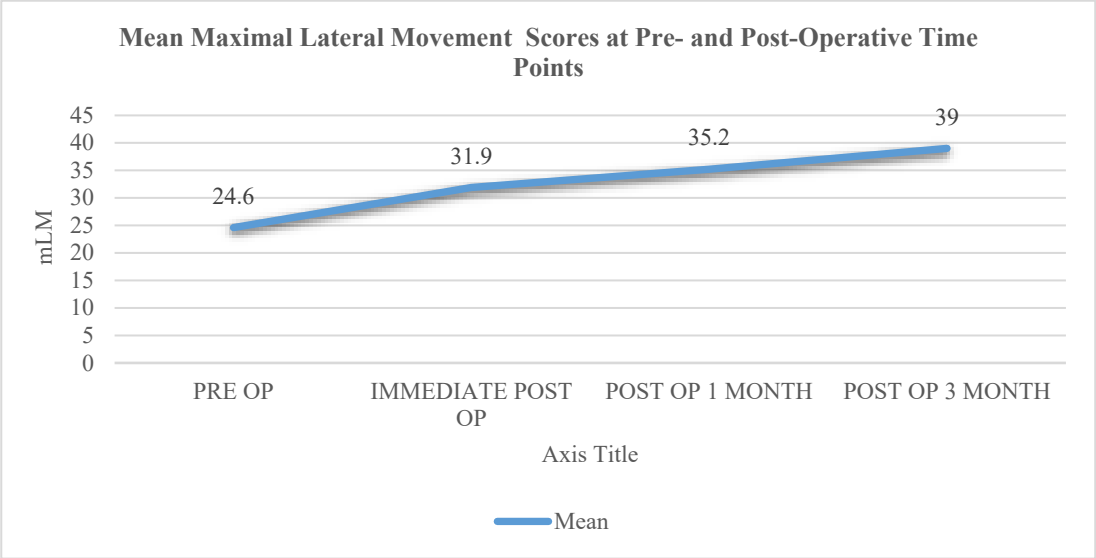


Figure 5. Line Figure showing Maximal Lateral Movement scores Across Pre- and Post-Operative Time Points

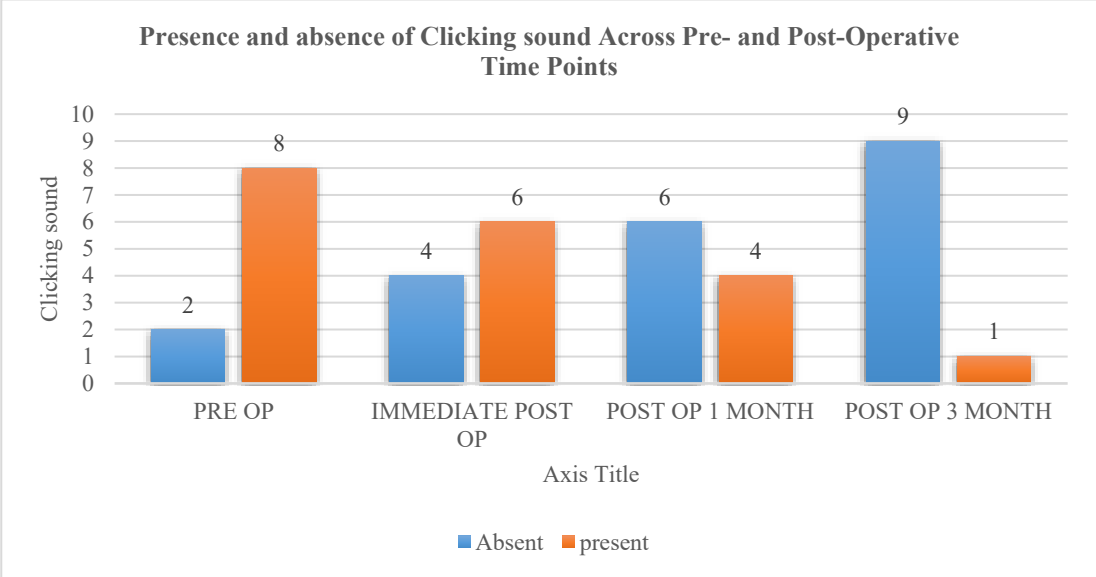


Figure 6. Bar Figure showing presence and absence of clicking sound across Pre- and Post-Operative Time Points

Conclusion

Automated irrigation arthrocentesis proved to be a safe, minimally invasive, and clinically effective treatment modality for temporomandibular joint internal derangement unresponsive to conservative therapy [8, 9, 24]. The technique resulted in consistent reduction in pain, progressive improvement in mouth opening and lateral mandibular movement, and complete resolution of joint clicking without intraoperative or postoperative complications [21-23, 33]. The use of a standard dental implant motor ensured constant hydraulic pressure, enhanced lavage efficiency, and reduced operator-dependent variability, making the procedure cost-effective and easily reproducible in routine outpatient practice [9].

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In these forms, the patients have given their consent for their clinical images and information to be reported in the journal. The patients understand that their names and initials will not be published and that due efforts will be made to conceal their identity; however, complete anonymity cannot be guaranteed [2].

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Conflict of interest: None

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Ethics statement: CDSCO Registration No. ECR/1967/Inst/TN/2024
Protocol No. SBDCH-IEC-CT-/11-04/11

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