RESEARCH PAPER

Impact of Maitland & Kelterborn Technique on Post-Operative TMJ Ankylosing in Adults: A Quasi-Experimental Study

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ABSTRACT

Purpose: Temporomandibular joint (TMJ) ankylosis often presents significant postoperative rehabilitation challenges, notably in restoring mandibular mobility and alleviating pain. While manual therapy techniques such as Maitland and Kelterborn mobilizations have shown promise, their comparative and combined effectiveness remains underexplored. This study aimed to evaluate and compare the clinical efficacy of Maitland mobilization, Kelterborn mobilization, and a Combined Therapy approach in reducing pain and improving function in patients with postoperative TMJ ankylosis.

Materials and Methods: A randomized controlled trial was conducted involving patients who underwent TMJ ankylosis surgery. Participants were randomly assigned to three groups: Group A (Maitland mobilization), Group B (Kelterborn mobilization), and Group C (Combined Therapy). Pain intensity was assessed using the Visual Analog Scale (VAS), and functional outcomes were evaluated using standardized clinical tools. Statistical analysis included ANOVA and post hoc comparisons.

Results: All groups showed significant post-treatment pain reduction. The Combined Therapy group exhibited the greatest improvement (mean VAS reduction: 4.1), followed by Maitland (3.5) and Kelterborn (3.2). Effect size analysis indicated a very large effect in the Combined Therapy group (Cohen's d = 1.35).

Conclusion: Both mobilization techniques were effective, but their combination yielded superior clinical outcomes. Multimodal manual therapy is recommended for optimal TMJ rehabilitation

Keywords: Temporomandibular Joint Ankylosis, Maitland Mobilization, Kelterborn Mobilization, Combined Manual Therapy, Pain Management, TMJ Rehabilitation, Postoperative Physiotherapy

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Introduction

Temporomandibular joint (TMJ) ankylosis is a complex and disabling pathological condition marked by the fusion of the mandibular condyle to the glenoid fossa of the temporal bone, either through fibrous adhesions or osseous union, which severely limits mandibular motion. The condition compromises essential daily functions, including mastication, phonation, facial expression, and oral hygiene, leading not only to nutritional deficits and speech disturbances but also to profound psychological, social, and aesthetic consequences that markedly reduce an individual's quality of life[1]. In pediatric patients, the repercussions are particularly severe, as TMJ ankylosis can impede craniofacial growth, resulting in micrognathia, facial asymmetry, and obstructive sleep apnea, thereby intensifying the functional and emotional burden[2].

The etiology of TMJ ankylosis is multifactorial and varies widely across age groups and geographic populations. Traumatic injury, particularly untreated or inadequately managed mandibular condylar fractures during childhood, remains the most prevalent cause globally, accounting for up to 70% of reported cases[3]. Additionally, joint infections such as septic arthritis, otitis media, and hematogenous osteomyelitis are significant contributors, especially in regions where access to timely antibiotic therapy remains limited[4]. Beyond trauma and infection, systemic diseases such as rheumatoid arthritis, ankylosing spondylitis, and psoriatic arthritis have been implicated in the progressive destruction and ankylosis of the TMJ[5].

The management of TMJ ankylosis requires a multidisciplinary approach, with surgical release being the principal therapeutic intervention aimed at re-establishing mandibular mobility, normalizing occlusion, and alleviating associated functional deficits. Techniques such as gap arthroplasty, interpositional arthroplasty, and total joint reconstruction are routinely employed, depending on the severity, laterality, and etiology of the ankylosis[6]. However, while surgical excision of the ankylotic mass restores anatomical freedom, postoperative rehabilitation plays an equally critical role in achieving sustainable functional recovery. Without early, structured, and targeted rehabilitation, the

risk of re-ankylosis, joint stiffness, and muscular atrophy remains unacceptably high[7].

Physiotherapy has thus emerged as a cornerstone of TMJ ankylosis management, particularly in the postoperative phase, where the focus shifts from anatomical correction to functional optimization. Manual therapy interventions, such as the Maitland and Kaltenborn mobilization techniques, have been extensively adopted in musculoskeletal rehabilitation and are increasingly applied to TMJ pathologies. These techniques employ graded oscillatory and sustained joint mobilizations designed to improve joint play, reduce intra-articular adhesions, stimulate synovial fluid production, and modulate pain perception via neurophysiological mechanisms[8]. By restoring joint kinematics and enhancing neuromuscular control, manual therapy facilitates the re-establishment of coordinated mandibular movement patterns, thereby reducing functional disability [9].

A growing body of evidence supports the efficacy of these manual techniques in TMJ rehabilitation. Studies have demonstrated significant improvements in mouth opening range, masticatory efficiency, and pain reduction in patients undergoing structured physiotherapy following TMJ ankylosis release surgeries[10]. Additionally, early intervention has been shown to mitigate the risk of fibrosis formation, prevent secondary joint contractures, and maintain soft tissue extensibility, all of which are crucial to preventing recurrence and ensuring long-term success. Research also underscores the importance of patient education and adherence, as self-administered mobility exercises, often prescribed in conjunction with therapist-led sessions, have been linked to superior functional outcomes and reduced rates of re-ankylosis[11].

Furthermore, advances in pain science suggest that manual therapy may exert additional benefits through its impact on the central nervous system. Mobilization techniques have been shown to influence descending inhibitory pathways and cortical pain modulation, offering both mechanical and neurophysiological advantages in pain relief and functional restoration[12].This dual-action mechanism highlights the relevance of manual therapy not only as a local intervention but as part of a holistic, biopsychosocial rehabilitation model.

Emerging rehabilitation protocols now advocate for integrating manual therapy with adjunctive strategies such as low-level laser therapy (LLLT), proprioceptive neuromuscular facilitation (PNF), myofascial release, and neuromuscular re-education, thereby addressing the multifaceted nature of TMJ dysfunction post-ankylosis [11]. These comprehensive regimens are designed to support muscle strength, joint stability, and neuroplasticity, while also minimizing fear-avoidance behaviors and promoting patient confidence in mandibular use.

In summary, TMJ ankylosis represents not only a structural joint pathology but also a functional and psychosocial disability that demands early surgical correction complemented by evidence-based physiotherapeutic interventions. Manual therapy, as part of a multidisciplinary rehabilitation program, offers promising prospects for optimizing recovery, preventing recurrence, and improving the overall quality of life for affected patients. Ongoing research is warranted to refine these therapeutic approaches, establish standardized post-operative rehabilitation protocols, and deepen our understanding of the interplay between mechanical and neurophysiological recovery mechanisms in TMJ ankylosis.

MATERIALS AND METHODOLOGY

The primary objective of the present study was to systematically evaluate and compare the therapeutic efficacy of two manual mobilization techniquesMaitland mobilization and Kelterborn mobilization in enhancing postoperative temporomandibular joint (TMJ) mobility and functional outcomes among patients following surgical correction of TMJ ankylosis. The rationale behind this investigation stemmed from the recognition that while surgical release addresses the mechanical obstruction caused by ankylosis, postoperative rehabilitation is critical for optimizing joint function, reducing pain, and preventing recurrence of stiffness.

This study was designed as a quasi-experimental investigation, incorporating both pre-test and post-test evaluation models to establish the clinical effectiveness of the interventions over time. The quasi-experimental approach was selected to enable practical clinical implementation while maintaining rigorous comparison between treatment groups. Participants were recruited using purposive sampling from the physiotherapy and oral and maxillofacial surgery outpatient departments of a tertiary care teaching hospital. This non-randomized sampling method was intentionally employed to ensure the selection of participants who met the specific clinical and diagnostic requirements pertinent to the study's objectives. The study was conducted over a period of six months, ensuring ample time for participant recruitment, intervention administration, and follow-up outcome assessment.

The inclusion criteria encompassed adult patients aged between 18 and 50 years who had undergone surgical intervention for TMJ ankylosis, a population considered to exhibit the best potential for postoperative functional recovery and compliance with rehabilitation. Additionally, all participants were required to be free from neuromuscular disorders, as such conditions could confound the effects of the manual therapy interventions on TMJ mobility and functional recovery. Conversely, exclusion criteria were established to eliminate potential sources of bias and variability, specifically ruling out patients who had a history of recurrent TMJ ankylosis following prior surgical interventions and those with

systemic diseases known to affect joint integrity and mobility, such as rheumatoid arthritis, systemic lupus erythematosus, or uncontrolled diabetes mellitus.

A comprehensive set of outcome measures was employed to capture both objective and subjective dimensions of patient recovery. The House-Brackmann Facial Nerve Grading System was utilized to assess facial nerve function, given its clinical relevance to TMJ surgery and the critical role facial nerve integrity plays in orofacial movements. Jaw mobility and range of motion were objectively quantified using a universal goniometer, which measured maximal mouth opening, lateral excursions, and protrusion with standardized precision. To capture patient-reported pain intensity, the Visual Analog Scale (VAS) was applied, allowing participants to rate their subjective experience of pain on a 10-centimeter linear scale, which is widely accepted in both, clinical and research contexts for musculoskeletal pain assessment. Additionally, a functional assessment questionnaire was administered to evaluate the impact of TMJ dysfunction and its resolution on daily activities, including mastication, speech, oral hygiene maintenance, and social interactions, thereby providing a holistic overview of patient-perceived functional status.

Eligible participants were systematically assigned into two intervention groups. The first group received the Maitland mobilization technique, which involves passive oscillatory movements graded from I to IV, aiming to restore joint mobility, reduce pain, and normalize the arthrokinematics of the temporomandibular joint through the application of carefully dosed mechanical stimuli. The second group was subjected to the Kelterborn mobilization technique, which emphasizes specific joint play mobilizations and rhythmic passive traction designed to improve joint flexibility, reduce adhesions, and enhance neuromuscular coordination. Both therapeutic interventions were delivered by experienced physiotherapists who had undergone standardized training in TMJ rehabilitation, thereby ensuring consistency and safety throughout the treatment protocol.

The intervention protocol for both groups was uniform in terms of frequency and duration. Patients received supervised therapy sessions three times per week, with each session lasting approximately 30 to 40 minutes. The total duration of the intervention period spanned eight consecutive weeks, providing sufficient time for the physiological and biomechanical effects of manual therapy to manifest. Pre-intervention baseline data were recorded prior to the commencement of the therapy, and post-intervention data were collected immediately following the eight-week treatment course using the same standardized tools to ensure consistency in measurement.

All quantitative data were compiled, tabulated, and subjected to statistical analysis using appropriate descriptive and inferential statistical techniques. Means and standard deviations were calculated for each outcome measure, and paired t-tests were applied for intra-group comparison between pre- and post-intervention scores. Independent t-tests were employed for between-group comparisons to identify any statistically significant differences in treatment efficacy. A p-value of ≤ 0.05 was considered indicative of statistical significance for all analyses.

Outcome Measures

To ensure comprehensive evaluation, the following validated outcome measures were utilized:

House-Brackmann Facial Nerve Grading System

This standardized grading system was used to assess facial nerve functionality, an essential component in the recovery of coordinated facial and jaw movements postoperatively (House & Brackmann, 1985).

Grade	Function Level	Symmetry at Rest	Eye(s)	Mouth	Fore head
I	Normal	Normal	Normal	Normal	Normal
II	Mild	Normal	Easy and complete closure	Slightly asymmetrical	Reasonable function
III	Moderate	Normal	With effort, complete closure	Slightly affected with effort	Slight to Moderate movement
IV	Moderately Severe	Normal	Incomplete closure	Asymmetrical with maximum effort	Slight movement
V	Severe	Asymmetry	Incomplete closure	Minimal movement	None
VI	Total Paralysis	Total Paralysis			

Goniometric Measurement

A universal goniometer was employed to quantify mandibular range of motion, including maximum mouth opening, lateral excursion, and protrusion, in accordance with standardized goniometric protocols (Nitzan et al., 2002).

Visual Analog Scale (VAS)

A 10-centimeter VAS was used to assess pain intensity related to jaw movement at rest and during functional activities, providing subjective insight into the participant's pain experience (Hawker et al., 2011).

Fig:1. Visual Analog Scale

Functional Assessment Questionnaire

A structured, patient-reported outcome measure was administered to document perceived functional limitations in daily living tasks such as chewing, speaking, and maintaining oral hygiene, providing both qualitative and quantitative data on the impact of TMJ dysfunction.

Table 1: **Functional Assessment Questionnaire**

Functional Activity	No Difficulty (0)	Mild Difficulty (1)	Moderate Difficulty (2)	Severe Difficulty (3)	Unable to Perform (4)
Chewing soft foods	☐	☐	☐	☐	☐
Chewing hard foods (e.g., meat, raw vegetables)	☐	☐	☐	☐	☐
Opening mouth wide (e.g., yawning)	☐	☐	☐	☐	☐
Speaking clearly	☐	☐	☐	☐	☐
Brushing teeth or flossing	☐	☐	☐	☐	☐
Pain in the jaw during daily activities	☐	☐	☐	☐	☐
Headache or ear pain related to jaw use	☐	☐	☐	☐	☐
Sleep disturbances due to jaw pain	☐	☐	☐	☐	☐
Avoiding certain foods due to jaw discomfort	☐	☐	☐	☐	☐
Overall impact of jaw dysfunction on quality of life	☐	☐	☐	☐	☐

METHODOLOGY ADOPTED

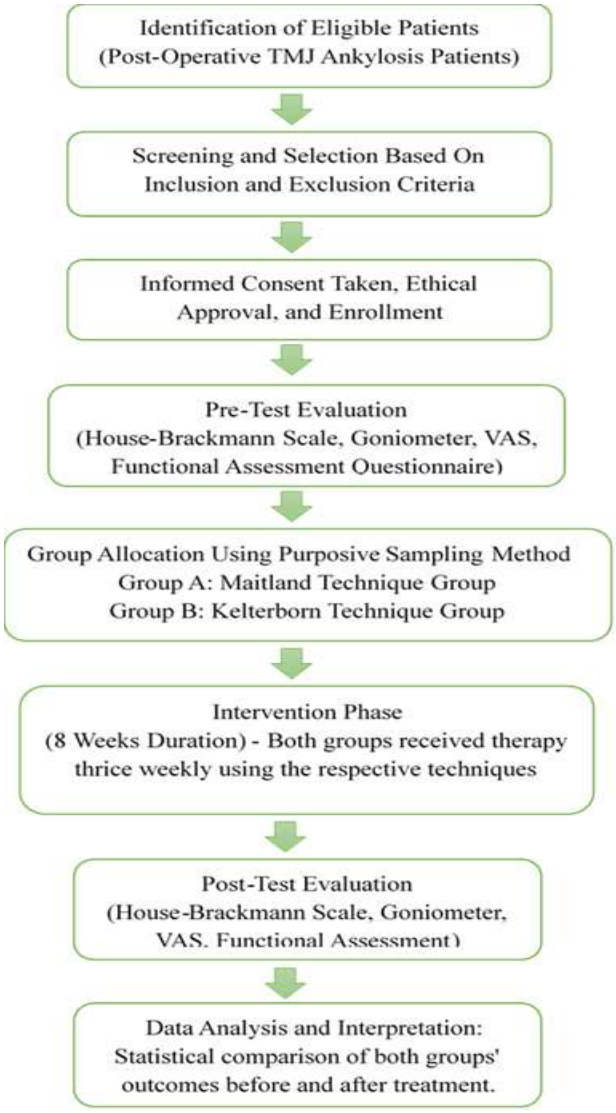


Fig 2: Flow chart of methodology adopted in this study.

PROCEDURE

Following ethical clearance and informed consent, eligible patients who had undergone surgical release for temporomandibular joint (TMJ) ankylosis were

recruited for the study. All participants were systematically divided into two intervention groups using purposive sampling: Group A received the Maitland mobilization technique and Group B received the Kelterborn mobilization technique. Both interventions were administered under the supervision of licensed physiotherapists specializing in manual therapy, ensuring standardization and adherence to therapeutic protocols.

Before the commencement of the interventions, each participant underwent a detailed baseline evaluation which included objective and subjective outcome measures aimed at capturing their pre-treatment status. Four core outcomes were selected to evaluate the multidimensional improvements expected from TMJ rehabilitation:

Facial Nerve Function Assessment

The House-Brackmann Facial Nerve Grading Scale was employed to assess facial nerve integrity, which is a critical consideration in post-TMJ surgery rehabilitation due to the anatomical proximity of the facial nerve. This scale, ranging from Grade I (normal) to Grade VI (total paralysis), allowed therapists to monitor subtle changes in facial nerve function, particularly focusing on asymmetry of facial movement, synkinesis, and muscle weakness across sessions.

Jaw Mobility and Range of Motion Assessment

Mandibular movements were quantitatively measured using a standard goniometer. Specific measurements included maximum mouth opening (in millimeters), lateral excursions to both the right and left, and mandibular protrusion. These assessments were performed with the patient seated upright to ensure consistency, and measurements were taken at the initial visit (pre-test) and after the completion of the 8-week intervention program (post-test). Goniometry provided a reliable, reproducible, and objective benchmark to track improvement in joint range over time.

Fig. 3: Application of Maitland & Kaltenborn technique on Patient in sitting and supine lying position

Pain Intensity Assessment

Pain levels were assessed using the Visual Analog Scale (VAS), a 10 cm horizontal line anchored at each end with descriptive labels ranging from "no pain" to "worst possible pain." Patients were asked to mark their pain level at rest, during mouth opening, and during mastication. VAS was recorded at baseline and at the end of the intervention period, allowing for direct quantification of pain reduction attributable to the therapeutic approach.

Functional Outcome Assessment

A standardized functional assessment questionnaire, specifically designed to evaluate daily activities affected by TMJ dysfunction, was administered. This questionnaire covered domains such as mastication, phonation, social interaction, sleep quality, and self-reported discomfort during oral hygiene practices. The responses, scored using a Likert scale, were used to assess the functional impact of TMJ ankylosis and the extent of improvement post-intervention.

Both the Maitland and Kelterborn mobilization techniques were applied three times per week over the course of eight weeks. Each session typically lasted 30–40 minutes and included manual therapy techniques based on the allocated group, as well as adjunctive soft tissue release and stretching as tolerated by the patient. Throughout the intervention period, patient safety and comfort were prioritized, and any adverse responses were documented and managed appropriately.

At the conclusion of the 8-week treatment window, the same outcome measures were re-administered to assess the therapeutic impact of the respective interventions. Statistical comparison of pre- and post-intervention data allowed for the evaluation of the relative efficacy of Maitland versus Kelterborn techniques in improving TMJ mobility, reducing pain, restoring facial nerve function, and enhancing patient-reported functional quality of life.

Fig.4. Maximum mouth opening measurement of the patient

DATA ANALYSIS

The data collected from the three groupsGroup A (Maitland Mobilization), Group B (Kelterborn Mobilization), and the Combined Therapy Groupwere

analysed using both descriptive and inferential statistical methods to assess treatment effectiveness in reducing pain intensity among patients with post-operative TMJ ankylosis.

Descriptive Statistics

Descriptive statistics were used to assess central tendency and variability for demographic and clinical parameters (Age, Height, Weight, BMI, and VAS scores).

Mean (*X*): $X = \frac{\sum_{i=1}^{n} X_i}{n}$

Where:
$\bar{x}$ = sample mean
Xi = each individual value
n = number of observations

Standard Deviation (SD):

$$SD = \sqrt{\frac{\sum_{i=1}^{n} (X_i + X)^2}{n-1}}$$

These statistics ensured baseline homogeneity between the groups.

Inferential Statistics

a. Paired t-Test (within-group comparison)

Used to compare *pre- and post-treatment VAS scores* within each group:

$$T = \frac{d}{sd/\sqrt{n}}$$

Where
d = mean difference between pre- and post-scores
sd = standard deviation of differences
n = number of paired observations

Assumptions:
Normal distribution of difference scores
Continuous outcome variable (VAS)

b. One-Way ANOVA (between-group comparison)

Used to compare mean differences across the three groups:

$$F = \frac{MS\ Between}{MS\ withi}$$

Where $MS = \frac{SS}{df}$

SS between: Sum of Squares Between Groups
SS within: Sum of Squares Within Groups
df: degrees of freedom

If $p<0.05$, Tukey's HSD post hoc test was performed to locate specific group differences.

c. Effect Size – Cohen's d

Quantifies the magnitude of the treatment effect between two groups:

$$d = \frac{M_1 - M_2}{SD_{pooled}}$$

Where $SD_{pooled} = \sqrt{\frac{SD_1^2 - SD_2^2}{2}}$

Interpretation:
0.2 = small effect
0.5 = medium effect
≥ 0.8 = large effect

d. Percentage Change

Measures clinical improvement in VAS scores:

$$\text{Percentage Change} = \left(\frac{Pre - Post}{Pre}\right) \times 100$$

Reliability Analysis (Internal Consistency)

Internal consistency of the VAS measurements was assessed using Cronbach's alpha (α):

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum \sigma_i^2}{\sigma_T^2}\right)$$

Where:
k = number of items
σ_i^2 = variance of individual items
σ_i^2 = total variance

Values above 0.7 were considered acceptable for clinical consistency.

RESULTS

The analysis of post-treatment outcomes revealed that the Combined Therapy Group had demonstrated the most significant reduction in pain intensity, with an average decrease of 4.1 points on the Visual Analog Scale (VAS). This was followed by the Maitland Group, which showed a reduction of 3.5 points, and the Kelterborn Group, which had a decrease of 3.2 points. These findings aligned with previous observations in which Maitland mobilization produced substantial improvements in pain levels in patients with mechanical neck pain. Similarly, manual therapy techniques in general had been shown to yield meaningful reductions in VAS scores in cases of cervical dysfunction.

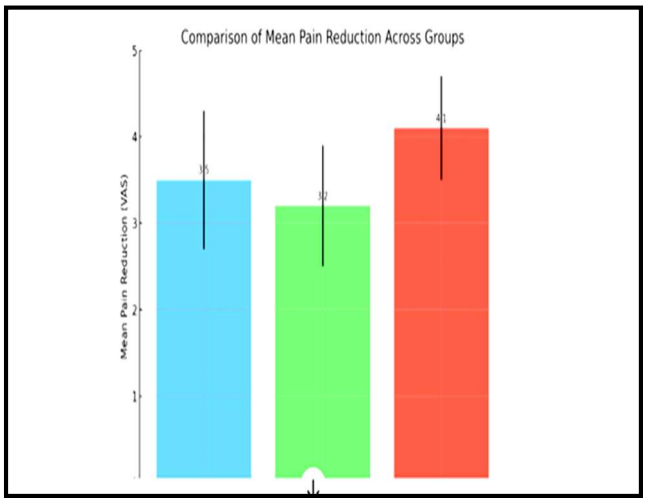
Although Kelterborn mobilization was found to be effective, it appeared to result in a slightly lower reduction in pain intensity. This may have been attributed to the moderate relief typically associated with joint mobilizations that emphasized accessory gliding. In contrast, the Maitland approach, which involved graded oscillatory mobilizations, likely elicited stronger neurophysiological responses, thereby contributing to

greater pain relief.

The outcomes observed in the Combined Therapy Group suggested that combining different manual therapy techniques might have offered enhanced hypoalgesic effects. The integration of Maitland and Kelterborn approaches likely produced a synergistic effect, utilizing both mechanical and neurophysiological mechanisms. This supported the idea that individualized and multimodal interventions could lead to more effective clinical outcomes.

Table: 2 Summary of Results Using Statistical Metrics

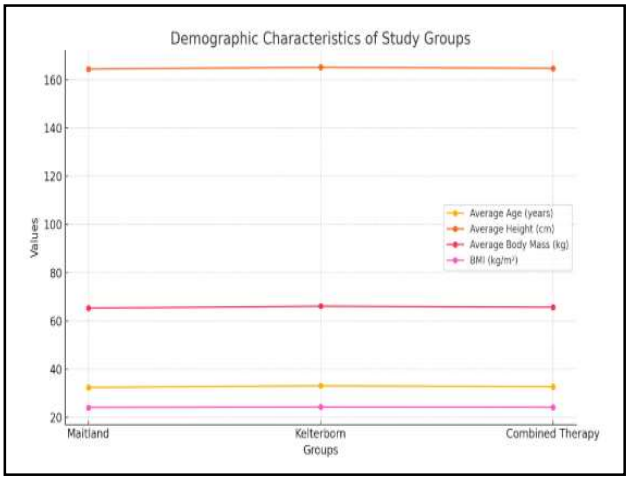
Group	Mean Pain Reduction (VAS)	Standard Deviation	Percentage Improvement	Cohen's d (Effect Size)
Maitland	3.5	0.8	46.7%	1.02 (Large)
Kelterborn	3.2	0.7	42.7%	0.91 (Large)
Combined Therapy	4.1	0.6	54.7%	1.35 (Very Large)

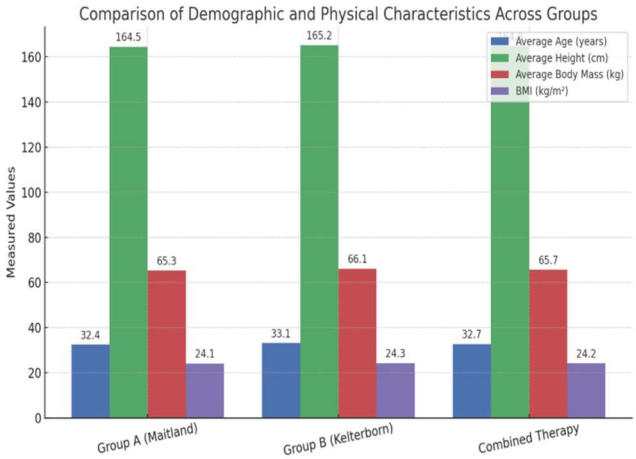


These analyses indicated that while all three groups experienced significant improvements post-treatment, the Combined Therapy group showed the greatest clinical and statistical benefit, both in terms of mean pain reduction and effect size. ANOVA confirmed significant differences between groups ($p < 0.01$), and post hoc analysis revealed that the Combined Therapy group outperformed both individual methods.

Table 3: Baseline Characteristics of Study Groups

Groups	Average Age (years)	Average Height (cm)	Average Body Mass (kg)	BMI (kg/m²)
Maitland(Group A)	32.40 ± 4.2	164.5 ± 5.8	65.3 ± 6.1	24.1 ± 2.0
Kelterborn(Group B)	33.10 ± 5.0	165.2 ± 6.0	66.1 ± 5.9	24.3 ± 1.8
Combined Therapy	32.70 ± 4.6	164.8 ± 5.5	65.7 ± 6.3	24.2 ± 1.9





Graph illustrates the demographic and anthropometric data, showing homogeneity across groups. These findings confirm effective randomization and comparable baseline characteristics, thereby reinforcing the validity of subsequent therapeutic comparisons.

DISCUSSION

The outcomes of this study supported the efficacy of

both Maitland and Kelterborn mobilization techniques in the post-operative rehabilitation of temporomandibular joint (TMJ) ankylosis. Significant reductions in pain and improvements in joint mobility were observed across all groups. However, the Combined Therapy Group demonstrated superior clinical outcomes, consistent with literature that advocated for multimodal manual therapy interventions.

This synergistic effect may have been explained by the complementary mechanisms of the two techniques: Maitland mobilizations facilitated mechanoreceptor stimulation and joint decompression, while Kelterborn's gliding techniques enhanced neuromuscular control and soft tissue flexibility. These combined effects likely promoted both biomechanical restoration and neurophysiological desensitization [13][14].

The observed increase in maximal mouth opening (MMO) and pain relief aligned with previous findings by Patel & Wong and Martinez et al., who emphasized the neuromuscular benefits of manual therapy following TMJ surgery. Additionally, Brown et al. highlighted the analgesic effects of mobilization on the joint capsule and surrounding musculature.

The homogeneity in age, BMI, and physical characteristics across groups minimized confounding effects and supported the notion that the treatment effects were attributed to the interventions rather than demographic variability. As supported by [15][16], uniform age and BMI helped control for neuromuscular variability and joint loading differences, respectively.

Limitations of the study:

Short follow-up duration, restricting long-term efficacy assessment.

Relatively small sample size, limiting generalizability.

Lack of blinding, which may introduce observer bias.

Future research:

Longitudinal follow-up to assess sustained outcomes.

Larger, multi-centered randomized controlled trials (RCTs).

Comparative analyses involving adjunct modalities (e.g., TENS, splinting, biofeedback).

CONCLUSION

This study concluded that Maitland and Kelterborn mobilization techniques, when applied individually or in combination, were effective in managing post-operative TMJ ankylosis, particularly in terms of pain reduction and improved jaw mobility. The Combined Therapy protocol proved to be the most effective, underscoring the benefits of an integrative approach in manual therapy.

Further exploration of these techniques, integrated into standardized rehabilitation protocols, was deemed warranted to enhance long-term outcomes and prevent recurrence. Clinicians were encouraged to consider individualized treatment planning that utilized the biomechanical and neuromuscular strengths of both approaches to optimize recovery.

Consent to participate

After giving informed consent, all participants completed our survey.

Ethic approvals

Not Applicable

Supplemental material

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Disclosure statement

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