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To cite this article: Steven Kraus & Janey Prodoehl (2017): Outcomes and patient satisfaction following individualized physical therapy treatment for patients diagnosed with temporomandibular disc displacement without reduction with limited opening: A cross-sectional study, CRANIO®, DOI: [10.1080/08869634.2017.1379260](https://doi.org/10.1080/08869634.2017.1379260)

To link to this article: <https://doi.org/10.1080/08869634.2017.1379260>



Published online: 04 Oct 2017.



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## Outcomes and patient satisfaction following individualized physical therapy treatment for patients diagnosed with temporomandibular disc displacement without reduction with limited opening: A cross-sectional study

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### ABSTRACT

**Objective:** To investigate physical therapy treatment outcomes and patient satisfaction in patients with a diagnosis of disc displacement without reduction with limited opening (DDWoR wLO).

**Methods:** Records of 97 patients with DDWoR wLO who received physical therapy in one outpatient clinic were used in this cross-sectional study. Outcomes included number of visits, maximum active interincisal opening, self-reported pain, and patient satisfaction.

**Results:** The average number of physical therapy visits per patient was 5.5, and there were significant improvements in pain rating and interincisal opening following physical therapy. Effect sizes for these comparisons were large (>1.0). Mean patient satisfaction responses across all symptom areas was consistent with patients being more than less satisfied following treatment.

**Discussion:** Individualized physical therapy treatment is an effective conservative intervention to improve mouth opening, reduce pain, and provide patient satisfaction in patients with one specific sub-type of temporomandibular disorder (TMD), DDWoR wLO.

### KEYWORDS

Temporomandibular joint disorders; treatment outcome; patient satisfaction; physical therapists; outcome assessment; disc displacement; physical therapy intervention; pain

### Introduction

Temporomandibular disorder (TMD) represents a constellation of signs and symptoms involving the temporomandibular joints (TMJs) and/or muscles of mastication. It has been estimated that up to 12% of the general population have experienced signs and symptoms of TMD [1–4] and that approximately one in five symptomatic individuals will seek treatment [5]. Treatment for TMD has become a costly venture for both patients and third party payers. Annual costs for the treatment of TMD have been estimated to be as high as \$4 billion [6]. TMD patients may see up to 3–5 healthcare professionals in search of relief, often resulting in no diagnosis, misdiagnosis, or an over diagnosis [7,8]. Deficiencies in the predoctoral healthcare professional's education on TMD may be a contributing factor for conflicting diagnoses and management. A goal of intervention for patients with TMD should be to provide cost-effective and evidence-based interventions to decrease suffering and improve participation in daily activities.

Patients with TMD are confronted with several treatment options, including surgery, various occlusal interventions, oral appliances, medication, behavioral therapy,

and physical therapy. However, conservative management is the recommended first line of treatment for patients with TMD [9,10]. Physical therapy (PT) is gaining recognition as an appropriate first line intervention for individuals with common myogenous and arthrogenous TMDs. Unfortunately, physical therapy is a term often used to describe the use of a treatment that does not always involve a licensed physical therapist. For example, healthcare professionals may refer to a home exercise program and heat application as physical therapy. Similarly, studies that negate the evidential support for the effectiveness of PT in the treatment of TMD may not define physical therapy appropriately. For example, Madani and Mirmortazav [11] examined the effectiveness of an oral appliance and physical therapy in the management of painful TMJ clicking and concluded appliance therapy was more effective than physical therapy. However, physical therapy was defined in that study as the application of ultrasound and electrical stimulation. Use of modalities alone does not constitute a comprehensive physical therapy plan of care. A clearer understanding for all healthcare professionals involved in the management of patients with

TMD of what individualized physical therapy would look like for patients with TMD is needed. While several recent randomized clinical trials and systematic reviews have examined the effectiveness of different aspects of physical therapy interventions for TMD [12–14], the strict adherence to randomization and tight experimental control of treatments offered may not be representative of the typical patient's experience with physical therapy treatment. The standard of care in physical therapy is such that treatment is individualized to a specific patient's needs and not applied identically across all patients based on a general diagnosis of TMD, as would be required in a randomized control trial. A clear understanding of the outcomes of physical therapy treatment and patient satisfaction for patients with TMD, utilizing an individualized plan of care mirroring best practice is needed.

The purpose of this novel study is to report outcomes and patient satisfaction for individuals with a primary diagnosis of disc displacement without reduction with limited opening (DDWoR wLO) following physical therapy treatment when utilizing an individualized treatment approach. DDWoR wLO was chosen for this study because of clear diagnostic criteria for diagnosing it. The results of this study will provide a clearer understanding for dental, medical, and physical therapy professionals and for prospective patients of what can be expected following physical therapy treatment using an individualized plan of care mirroring current best practice.

## Materials and methods

The institutional review board at Physiotherapy Associates approved this study. All patients to this practice provided informed consent for their records to be used at the time of the initial visit, and this study followed the principles of the Declaration of Helsinki. New patients were evaluated from patients referred by a dental professional to one outpatient physical therapy clinic run by the primary author who is a licensed PT with clinical experience examining and treating individuals with TMD. All patients completed a medical history questionnaire, symptom questionnaire, and a symptom location diagram on initial visit. The diagnostic guidelines used by the physical therapist to diagnose DDWoR wLO were positive for both a prior history of clicking with or without intermittent locking and a current report of limited jaw opening sufficient enough to limit mouth opening to interfere with chewing, yawning, and brushing of teeth in the history as well as maximum active inter-incisal mouth opening of  $\leq 30$  mm without correction of vertical incisal overlap on examination [15]. Diagnostic accuracy of the physical therapist to diagnose a DDWoR wLO for this population of 97 patients has previously been shown to have acceptable values for overall

**Table 1.** Details of 97 patients treated in physical therapy for disc displacement without reduction.

Age	39.9 (15.6)
Number of females (males)	90 (7)
Number of physical therapy visits (range)	5.5 (1–27)
Pre-treatment opening distance without pain (mm)	21.7 (5.3)
Pre-treatment opening distance with pain (mm)	26.3 (4.1)
Post-treatment opening distance with/without pain (mm)	35.2 (5.0)
Pre-treatment pain rating (0–10 scale)	3.9 (2.3)
Post-treatment pain rating (0–10 scale)	1.4 (2.0)

Note: Data are given as mean (standard deviation, SD) unless otherwise noted.

diagnostic accuracy [15]. A total of 97 patients met the inclusion criteria. Demographic and baseline data are provided in Table 1.

## Inclusion criteria

The specific initial inclusion criteria for this study were: (1) patients had to be referred to the physical therapy practice by a dentist; (2) patients could not have symptoms arising from active pathology of the head, face, jaw, and/or dentition; (3) patients had to be able to complete a medical history questionnaire, symptom questionnaire, a symptom location diagram questionnaire, and had to respond to verbal questions during the examination without assistance, and; (4) patients had to be diagnosed with DDWoR wLO by the PT [15].

Onset for the 97 patients diagnosed with DDWoR wLO was varied. The majority of patients (69%) had an insidious onset. Average duration of onset for all 97 patients was 3 months, with a range of less than a week to more than 5 years. Fifty-two of the 97 patients had worn or were wearing an oral appliance. Ten different oral appliance designs were identified, of which the most common was a full coverage maxillary appliance. Fifty-three of the 97 patients admitted to taking non-steroidal anti-inflammatory (NSAID) medication, with 68 patients taking any combination of NSAIDs, aspirin, and Tylenol.

## Outcomes

The primary outcome measures were the number of treatment visits completed, maximum active interincisal opening, and self-reported pain rating ( $n = 97$ ). For interincisal opening, pre-treatment measures were taken of maximal opening distance (with- and without-pain), using a ruler to measure the distance between the maxillary and mandibular central incisors (mm) [16]. Post intervention opening measurements were also taken. The primary author collected all measurements throughout the study and treated all patients. Risk of bias could not be eliminated but was minimized by having a standardized data collection protocol. Patients rated their pain intensity

using a written Numeric Pain Rating Scale (0 = no pain, 10 = maximal pain) at the initial visit and at the last visit [17]. Final pain rating could not be determined in 8 patients, due to non-response to follow-up, making the final sample for analysis of pre to post change in pain rating 89 patients.

A secondary outcome measure was patient satisfaction, as assessed by the responses on a mailed questionnaire. Approximately eight weeks following the last physical therapy visit, each patient was mailed a one-page patient satisfaction questionnaire, along with a stamped return envelope. If the questionnaire was not returned, a reminder phone call was made to the patient. The survey return rate was 74%. The questionnaire consisted of one primary question: "How much did physical therapy help you with the following symptoms/problems?" with 0–10 Likert scale answer options related to 12 different symptoms or problems. Subjects were asked to circle the number that best indicated their response related to a particular symptom or problem, where 0 represented "Did not help" and 10 represented "Helped a great deal." Subjects had the option to check a box that indicated they did not have a particular symptom or problem at the time of therapy if it was not relevant to them. The 12 symptoms/problems assessed were: Headache, Jaw pain/tension, Limited mouth opening, Jaw popping, Jaw locking, Pain with chewing, Clenching/grinding of teeth, Neck and shoulder pain/tension, Waking up at night due to headache/jaw/neck pain, Headache/jaw/neck pain while sitting, Ear pain/ringing/fullness/other, and Dizziness. Subjects were also asked one overall satisfaction question: "If your symptoms/problems were to return in the future, would you return to physical therapy?" Subjects were asked to add a check to either "No," "Maybe," or "Absolutely" response options.

### Interventions

General intervention strategies for the individuals with DDWoR wLO are shown in Table 2. Treatment strategies for each patient were individualized around these general strategies. A single modality or procedure is rarely utilized by a physical therapist in treatment. Concurrent diagnostic subsets such as arthralgia and/or myalgia and the common comorbidity of cervical spine pain were considered in formulating treatment strategies for each individual patient diagnosed with DDWoR wLO. The PT assessed the patient's response at the time of treatment and reassessed the patient's status before initiating the next treatment session in order to determine if treatment parameters should be modified and how treatment should be progressed. Treatment objectives were to decrease pain and increase mouth opening that was

both functional and satisfactory to the individual patient. Treatment options and sequence of treatments for DDWoR wLO were based on the findings of the clinical examination and clinical reasoning. Clinical reasoning factored in several variables including, but not limited to, duration of onset (acute or chronic) and mechanism of onset (trauma vs. onset as a continuation of the natural history associated with a disc displacement) and previously mentioned concurrent diagnostic subsets of TMD and cervical spine pain. Patient education played an important role in the treatment of all patients. In instances when patients expressed an enhanced psychosocial distress of fear, anger, anxiety, depression, or inaccurate beliefs about their condition, which often resulted from misinformation received from family, friends or other healthcare professionals, a more in-depth patient education addressing such inaccurate information was delivered. The average treatment session length was 45–60 min. Recommended treatment frequency was once per week for six weeks, but this was modified based on patient response. If a patient was showing improvement in mouth opening and reduced pain, treatment was progressed, if necessary, to add more repetitions of stretching and a return to unrestricted functional activities with reduced focus on pain relief. If a patient showed increased pain, focus was returned to reducing pain symptoms and maximizing joint protected movement strategies and minimizing joint loading. If a patient showed no change in interincisal opening and pain was not a priority, activities were progressed to higher grades of mobilization or stretching. Patients who reached the six-week or six visit mark were reevaluated to determine if additional therapy was needed.

### Statistics

Primary outcome measures comparing pre- to post-treatment were assessed with dependent samples *t*-tests, using IBM SPSS Statistics 22 (Statistical Package for the Social Sciences, Chicago, IL, USA). Effect sizes were calculated using Cohen's *d* statistic with confidence intervals at the 95th percentile (CI 95%). Effect sizes were interpreted in accordance with Cohen's convention of  $\leq 0.2$  representing a small change, 0.5 representing a moderate change, and  $\geq 0.8$  representing a large change [24]. Descriptive measures were applied to secondary outcomes of number of treatment visits and patient satisfaction. A multivariate analysis of variance (MANOVA) was performed to assess whether the change in pain level or change in opening distance following treatment accounted significantly for post-treatment patient satisfaction ratings. Statistical tests were two sided, and significance was determined using a *p* value  $< 0.05$ .

**Table 2.** Intervention strategies used in the individualized treatment plans for patients with DDWoR wLO<sup>a</sup>.

Treatment strategy	Description
Patient education	Patients were educated that the disc does not have to be in place to have “successful” treatment outcomes. Patients were reassured about the harmless nature of a disc displacement. Education was intended to reduce unnecessary fear, anxiety, and inaccurate beliefs about their condition, which would have interfered with achieving optimal treatment outcomes [18]. Other treatment options that are available other than physical therapy were always discussed. This includes treatments that are intended to reposition the disc, such as the wearing of an anterior repositioning appliance or arthroscopy (discoplasty) to treatments that are not intended to reposition the disc, such as arthrocentesis, arthroscopy, and doing nothing. Pros and cons of all treatments were discussed with each patient based on the scientific evidence available or lacking. Expectations of physical therapy treatments were discussed with the patient pertaining to treatment frequency, duration of a treatment visit, cost of treatment, objectives, and expected treatment outcomes.
Behavioral modification	Behavioral modification is defined here as the direct changing of unwanted behavior by means of biofeedback or conditioning. Biofeedback in this instance did not include the use of electronic monitoring. Instead, patients were instructed on changing their behaviors, i.e. behavioral modification. Goals for incorporating behavioral modification focused on the relaxation of the muscles of mastication to decrease joint loading to assist in the management of DDWoR wLO. Behavioral modification began with instruction related to choosing a non-painful diet and eliminating harmful parafunctional activities, including gum chewing, chewing ice, and fingernail biting. Behavioral modification also incorporated cognitive awareness exercises. Cognitive awareness exercises are done for the purpose of reducing bruxism and / or jaw bracing activity that often occurs during activities of exertion (lifting / carrying objects), focused concentration (working at a computer, driving, listening during a conversation), and when a patient is subjected to stress. Behavioral modification also included correction of poor sitting ergonomics, which could contribute to neck pain that may lead to enhancing masticatory muscle activity. Controlling nocturnal bruxism and / or bracing activity was more challenging, but patient education included modifying sleeping postures by avoiding stomach sleeping and keeping hands away from the face when side-sleeping. Proper cervical pillow support for the jaw and neck when side lying and supine was demonstrated to assist in reducing unnecessary pressure on the jaw and neck.
Therapeutic exercise	Therapeutic exercise was defined as any exercise planned and performed with the aim of improving a single parameter, such as strength, range of motion (ROM), flexibility, or endurance. Therapeutic exercise consisted of active and passive jaw stretching exercises performed by the patient or active assistive and passive jaw stretching exercises performed on the patient by the therapist, with the goal of improving ROM to achieve functional mandibular dynamics during opening, protrusive, and lateral excursions. For some patients, a static stretch exercise of placing tongue depressors between the molars was necessary. Strengthening exercises for the muscles of mastication are rarely indicated.
Neuromuscular reeducation	As mobility of the TMJ improves, neuromuscular reeducation exercises were introduced. Neuromuscular reeducation was defined as the reeducation of movement, balance, kinesthetic sense, posture, and proprioception. Depending on the duration the patient had been limited in moving his or her mandible, kinesthetic and proprioceptive exercises were used to enhance TMJ mechanoreceptors activity.
Manual therapy	Manual therapy consisted of joint mobilization and/or soft tissue mobilization: <i>Joint Mobilization</i> – the act of moving articular structures generally performed passively by the PT or actively assisted by the patient, with appropriate positioning to facilitate the intended movement. Intraoral techniques directed towards the condyle, consisting of arthrokinematic techniques to promote joint distraction and condylar translation in an anterior and/or anterior medial direction. <i>Soft tissue mobilization</i> – the movement of contractile or inert tissues in such a way as to effect change in that structure or its related elements. The treatment was applied specifically by the PT at targeted tissues, i.e. muscles of mastication to treat myalgia to assist in restoring tissue mobility. This included treatment of both active and latent myofascial trigger points with stretching techniques or sustained trigger point pressure [19].
Modalities	<i>Ultrasound (US)</i> is a form of acoustic energy (a sound wave that has a frequency greater than 20 kHz) utilized for its thermal and non-thermal effects. The thermal effect of US can have a depth of penetration of 3–5 cm. Non-thermal effects include micromassage (microscopic movement of fluids and tissues), which leads to an increase in membrane permeability and arterial vasodilation. Therapeutic ultrasound has been used to stimulate the repair of soft tissue injuries and to relieve pain. Pulsed ultrasound can be used to enhance transdermal transport of several drugs, which is referred to as phonophoresis. Phonophoresis is superior to topical application for increasing the concentration of certain medications in synovial tissues. Pulsed ultrasound provided the most effective condition for delivering medication [20,21]. <i>Iontophoresis</i> is the process by which drugs, usually anti-inflammatory in nature, are introduced to a small body part via electrical current. It is non-invasive, painless, and eliminates potential side effects and adverse reactions, which can occur with medications delivered orally or by injection. Pertinent to DDWoR wLO are associated concurrent conditions such as TMJ arthralgia and myalgia of the masseter muscle that would best respond to iontophoresis [22,23]. <i>Interferential Stimulation</i> is a type of electrical stimulation used for the control of pain. Interferential currents are believed to penetrate to deeper tissues than other forms of electrical stimulation, such as transcutaneous electrical stimulations (TENS), and due to decreased skin resistance with stimulation at higher frequencies, patients may better tolerate interferential current than TENS, especially when applied over the masseter and / or TMJs. To avoid the cross over effect as with true interferential, premodulated interferential stimulation was used with a setting of 10–15 s on and 10–15 s off. The intermittent current provides an environment allowing for graded exercises, cueing the patient when to perform various active, passive, and cognitive awareness exercises at the same time receiving the benefits from premodulation interferential current of analgesia, edema reduction, and muscle guarding reduction.

<sup>a</sup>DDWoR wLO disc displacement without reduction with limited opening.

## Results

### Primary outcomes

The average number of physical therapy visits per patient was 5.5 (range 1–27). Twelve percent of the patients had 1 treatment visit ( $n = 12$ ), 22% of patients had 2–3 treatment

visits ( $n = 21$ ), 38% had between 4 and 6 treatment visits ( $n = 37$ ), 20% had between 7 and 10 treatment visits ( $n = 19$ ), and 8% had 11 treatment visits or more ( $n = 8$ ). Not all patients followed the recommended treatment frequency. Some patients responded within 1–2 sessions, while other patients were unable to complete the number

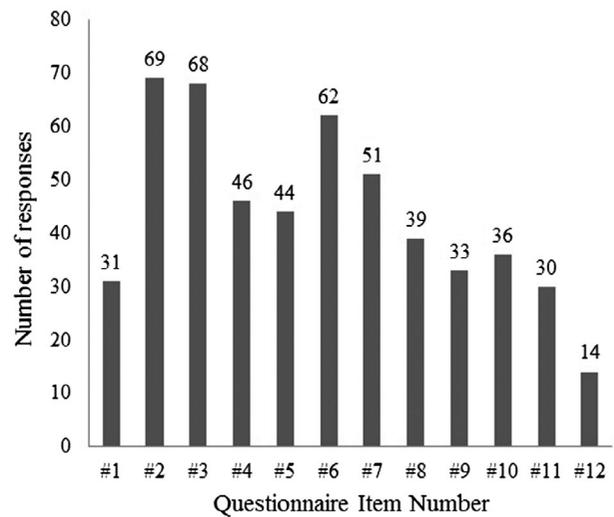
of visits because of circumstance related to scheduling, work, family, finances, or travel distance.

Maximal mouth opening improved after treatment (Table 1). The average interincisal opening improvement was approximately 9 mm (pre-opening with pain distance compared to post-opening distance) to 13 mm (pre-opening without pain distance compared to post-opening distance). The average post-treatment opening interincisal opening with/without pain was 35.2 mm (Table 1). This change was significant for both pre-opening with pain ( $t(96) = -16.2, p = .000; d = 1.95, CI\ 95\% = 1.60, 2.28$ ) and pre-opening without pain ( $t(96) = -14.8, p = .000; d = 2.62, CI\ 95\% = 2.21, 2.98$ ). The effect sizes for these comparisons were consistent with a large effect size. Similarly, patients' self-reported pain rating significantly improved after treatment ( $t(88) = 8.1, p = .000; d = 1.15, CI\ 95\% = 0.83, 1.46$ ). The average improvement in pain was approximately 2.5 points, and the effect size for this change was consistent with a large effect size.

### Secondary outcomes

Seventy-two of the 97 patients (74%) returned the mailed survey. Of the 12 satisfaction questionnaire symptom/problem areas, the top 3 that generated responses were questions related to whether physical therapy helped with jaw pain/tension, limited mouth opening, and pain with chewing (Figure 1). These three symptom/problem areas were the most frequent complaints reported by individuals with DDWoR wLO. A breakdown of responses across the 12-symptom/problem areas assessed by questionnaire is given in Table 3. The mean patient satisfaction response across all 12 symptom/problem areas was 6.8 (SD 0.6), suggesting that on average, patients were more satisfied than less satisfied following treatment. After the course of physical therapy, 88 patients responded to the general satisfaction question of "If your symptoms/problems were to return in the future, would you return to physical therapy?" Of those 88 patients, 67 patients (76%) answered "Absolutely," 13 answered "Maybe" (15%), and 8 answered "No" (9%).

The results of the MANOVA showed that respondents who indicated different levels of overall satisfaction ("Absolutely," "Maybe," and "No" to returning for physical



**Figure 1.** Responses by count to post-treatment Patient Satisfaction Questionnaire.

Notes: Item numbers refer to 12 different symptom/problem areas where # = item number: #1 = Headache, #2 = Jaw pain/tension, #3 = Limited mouth opening, #4 = Jaw popping, #5 = Jaw locking, #6 = Pain with chewing, #7 = Clenching/grinding of teeth, #8 = Neck and shoulder pain/tension, #9 = Waking up at night due to headache/jaw/neck pain, #10 = Headache/jaw/neck pain while sitting, #11 = Ear pain/ringing/fullness/other, and #12 = Dizziness.

therapy in the future if the symptoms/problems were to return) demonstrated different amounts of mean change in opening with pain distance ( $F(2,78) = 5.44, p = .006$ ). Specifically, *post hoc* tests revealed that those patients who responded "Absolutely" to returning (mean change 10.1 mm, SD 4.7) had a significantly higher mean change in opening distance than those patients who responded "No" to returning in the future (mean change 4.7 mm, SD 3.7). Conversely, patients who answered "Maybe" to returning for treatment in the future (mean change 6.7 mm, SD 7.4) did not significantly differ from either the "Absolutely" or the "No" groups. No significant differences across level of satisfaction were observed for change in opening without pain distance ( $F(2,78) = 2.594, p = .081$ ) or overall change in pain rating ( $F(2,78) = 2.499, p = .089$ ).

### Discussion

This paper reports novel findings about the outcomes following individualized physical therapy in patients

**Table 3.** Patient reported satisfaction following physical therapy intervention.

	Patient satisfaction questionnaire items*											
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Mean (SD)	6.8 (2.4)	7.2 (2.7)	7.8 (2.2)	6.2 (3.1)	7.9 (2.5)	7.0 (2.9)	6.1 (2.6)	6.9 (2.6)	6.4 (3.0)	6.7 (2.8)	6.4 (2.6)	6.2 (2.4)

Notes: Responses were on a Likert scale, where a score of 0 represented "Did not help" and a score of 10 represented "Helped a great deal."

\*Item numbers refer to 12 different symptom/problem areas, where # = item number on questionnaire: #1 = Headache; #2 = Jaw pain/tension; #3 = Limited mouth opening; #4 = Jaw popping; #5 = Jaw locking; #6 = Pain with chewing; #7 = Clenching/grinding of teeth; #8 = Neck and shoulder pain/tension; #9 = Waking up at night due to headache/jaw/neck pain; #10 = Headache/jaw/neck pain while sitting; #11 = Ear pain/ringing/fullness/other; and #12 = Dizziness.

diagnosed with DDWoR wLO. On average, patients attended 5.5 physical therapy visits, and outcomes were very good related to improvements in mouth opening, self-reported pain intensity, and patient satisfaction with large treatment effect sizes ( $>1.0$ ). While this study was not designed to examine cost of care, approximate costs could be retrospectively assessed to estimate the cost of treatment. The authors very conservatively estimated that the average cost for patients paying out-of-pocket for 5.5 physical therapy visits would have been approximately \$483 (\$100 for the initial evaluation and treatment session and \$85 for subsequent treatment sessions), with this amount being less for patients using insurance. Taken together with the findings from this study, this provides support for individualized physical therapy as a viable treatment for patients with DDwoR wLO. The findings provide insight into what referring dentists, physicians, and patients with a diagnosis of DDWoR wLO could expect regarding physical therapy treatment when referred to a physical therapist who specializes in the treatment of TMD and cervical spine disorders [25] and individualized care is instituted.

Results of studies examining the success of different conservative treatment options have provided mixed results, largely due to methodology issues and not having a homogeneous study population. However, even given a specific diagnostic classification, it seems appropriate that management of patients should be considered on an individual patient basis, accepting that not all patients will respond to a particular treatment in the same way. This is supported by the results of the current study. Not all patients responded exactly the same to treatment, as shown by the range in number of visits. Mouth opening was significantly improved from pre- to post-treatment for the group of patients as a whole, and treatment effect sizes were large, suggesting clinical significance of the change in outcome scores. Similarly, pain was significantly reduced post-treatment. Patients who were the most satisfied with treatment across all categories assessed tended to have greater improvements in mouth opening, whereas change in pain rating did not account significantly for overall patient satisfaction. Although this suggests that restoring range of motion was more important to patients with DDwoR wLO than reducing pain; pain is such a subjective experience that the symptom/problem areas examined may not have adequately captured the patient's priority regarding pain management. In addition, the 12-symptom/problem areas examined can have multiple etiologies, and patient satisfaction for different etiologies should be further examined. While the majority of patients (76%) noted that they "absolutely" would return to physical therapy if needed, 24% were less sure. Further study is warranted to understand the reasons why some patients do not achieve the results that they want or need, even when an appropriate individualized physical therapy plan of care is implemented.

Physical therapy may not be necessary for all patients with a DDWoR wLO. Previous studies have shown that a number of patients diagnosed with a DDWoR wLO can improve on their own in terms of a reduction in pain and improved mouth opening [26–28]. Additionally, a patient's symptomology and functional limitations may be at a level that they feel they can manage themselves. However, this option may not be appealing to those patients who are impatient to allow for the natural history of the condition to progress, especially considering the functional restriction and quality of life issues that occur with limited use of the jaw and chronic pain related to TMD. The patients in the current study actively sought treatment from their dentist because they were not willing to wait for resolution of symptoms or their symptoms were progressively getting worse. The results of the current study support that physical therapy was beneficial for the majority of patients in the study and provides some information to referring dentists on what individualized physical therapy treatment can look like. However, given that this was not a randomized control trial, it cannot be said that patients improved solely because of the treatment they received. Previous systematic reviews have shown effectiveness of conservative treatment for disc displacement without reduction. A recent systematic review, which examined the effectiveness of physical therapy interventions for TMD, supported the use of active and passive oral exercise, manual therapy, and postural exercises as effective interventions to reduce TMD symptoms, although the quality of included studies was generally poor [12]. Consistent with this, another systematic review examining management of TMD concluded that while there is some evidence to support the use of a variety of conservative treatments to alleviate TMD pain, the considerable heterogeneity in methodology among studies makes it difficult to form definitive conclusions about treatment effectiveness [29]. The results of the current study provide different information than that from systematic reviews, in that this study showed how patients seen in an outpatient PT practice diagnosed with a DDwoR wLO responded to an individualized plan of care and how satisfied they were with their outcome.

There are several limitations to this study that should be considered. Because this study utilized a sample of convenience, the reproducibility of the results will be affected, and this may have inflated the effect sizes. However, the authors have no reason to believe that the results could not be generalized to patients seeking care from any physical therapist with post-professional training and experience working with patients with TMD, headache, and orofacial pain. This will only be confirmed through reproducibility of results across other physical therapy practices. While physical therapists with experience in treating people with

musculoskeletal problems may work with individuals with TMD, some physical therapists have a practice with a specific craniofacial focus, having taken continuing education courses in orofacial pain. Some physical therapists are either board-certified orthopedic clinical specialists, have completed a residency or fellowship in orthopedic physical therapy, which may have included an orofacial component, or have post professional certifications specifically in orofacial pain [25]. Newer treatment tools used in TMD management, specifically trigger point dry needling [30,31], were not available at the time of data collection, and utilizing these tools now might alter patient response across physical therapy practices. Dry needling is a skilled intervention that uses a thin filiform needle without injectate to penetrate the skin and stimulate underlying myofascial trigger points, muscular, and connective tissues for the management of neuromusculoskeletal pain and movement impairments [30]. Also, while this study examined outcomes from physical therapy treatment, other treatment options offered by physicians or dentists, such as joint injection or appliance therapy, could be considered in the management of these patients. Data collection by the treating therapist also introduced the possibility of bias. In addition, the cross sectional nature of the study and the lack of a no-treatment control group with randomization does not make it possible to say that positive outcomes were specifically related to the intervention alone and not to other factors. The lack of longer-term follow-up makes it impossible to assess whether the treatment effects were maintained by all patients in the study. Though an average of eight months occurred between the time the patient was last seen for treatment and when the surveys were returned, the authors are not aware of any follow-up studies in this population that assessed the benefits of PT over the long-term. In the absence of those studies, this study at least suggests a positive trend for the long-term benefits of PT for patients with DDWoR wLO. In addition to long-term follow up, future studies should consider the use of validated measures of functional limitation and self-perceived pain/disability, which was missing from this study, and with hindsight, would have added an important aspect to understanding patient outcomes. Outcome measures to assess biopsychosocial distress utilizing the Jaw Functional Limitation Scale and the Graded Chronic Pain Scale [32–34], for example, could to be incorporated in future studies.

## Conclusion

In this study, patients received physical therapy treatments for an average of 5.5 physical therapy visits, which was retrospectively and roughly assessed to be at a reasonable cost. Improvements in pain rating and mouth opening were noted, and effect sizes of change were large (>1.0),

suggesting clinical significance of the results. Restoring mouth opening rather than reducing pain significantly accounted for patient satisfaction post-treatment. Consistent with current best practice recommendations, unless there are specific and justifiable indications to the contrary, dentists, oral surgeons, physicians, patients, and insurance companies that are interested in a conservative and cost effective treatment for TMD should consider involving the services of a physical therapist trained in the evaluation and treatment of TMD.

## Disclosure statement

The authors report no conflict of interest and did not receive any funding support for this project.

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