Anterior repositioning splint treatment consideration for cases of disc displacement with reduction

[1]Steven Alexander Tjang, [2]Ira Tanti
[1]Prosthodontic Residency Program
[2]Prosthodontic Department
Faculty of Dentistry, Indonesia University
Jakarta, Indonesia
Corresponding author: **Ira Tanty**, email: **iratanti@ymail.com**

ABSTRACT
The focus of this literature review is to explore the process of disc displacement with reduction (DDWR) and how the treatment using anterior repositioning splint (ARS) can positively affect patients who are diagnosed with DDWR. The use of MRI as the gold standard of TMJ study allows current researcher to re-consider the common theory whereby DDWR ultimately progresses into disc displacement without reduction or other advanced internal derangement process. The use of ARS can produce resolution of pain in patients who are experiencing DDWR with joint pain. However, the use of ARS is shown to be effective on short term only, and its use must be accompanied by other modalities such as physical self-regulation (PSR). The lack of gold standard for the treatment of DDWR prompts healthcare worker to provide patients with conservative treatment before offering more advanced and sur-gical procedure, both of which carries additional unwanted risk. Overall, the use of ARS is shown to be very effective and non-invasive.
Keywords: disc displacement with reduction, anterior repositioning splint, TMD

INTRODUCTION

Temporomandibular disorder (TMD) is a group of conditions that involve masticatory muscles, temporomandibular joint (TMJ) and the surrounding structures. Generally, the term intercapsular disorders involves muscles of mastication, whilst intracapsular disorder involves temporomandibular joint complex. From the myriads of intracapsular disorder variations, disc displacement with reduction (DDWR) conditions comprises of 41% of the diagnoses of TMD that is often founded by clinician.[1] Observation of the condition of DDWR under magnetic resonance imaging (MRI) show articular disc position located more anteriorly than normal during maximum intercuspation. During mouth opening, articular disc will return to a normal position, whereby the returning motion of condyle to normal position from anterior position creates the clicking sound. DDWR can be accompanied with pain or without pain. A recent publications show 31% of patients has no signs of painful condition.[2]

Correlation between pain and TMD is still a matter of debate. Okeson explained that intracapsular disorder can occur on patients with orthopedically unstable TMJ as well as unfavorable masticatory force. However, not all orthopedically unstable TMJ will lead to intracapsular disorder, and therefore therapy is not always indicated.[1] The high prevalence of DDWR among general population causes confusion for both patient and clinicians in terms of the risk factor associated with the progression on DDWR. A literature review is important to determine whether DDWR treatment will be needed and/or the degree of treatment that can be provided for patient.[2]

The use of anterior repositioning splint (ARS) has been known as one of the treatment alternatives for DDWR with a good success rate. A short-term use of ARS has been shown to be able to reduce painful symptom associated with DDWR. However, several researchers found that the long-term use of ASR can cause relapse to DDWR, making articular disc condition return to a state before treatment.[2,3]

This literature review will revisit DDWR, its progression, the need to alleviate the condition and ultimately to determine whether the use of ARS can become a routine procedure to treat and resolve DDWR that often becomes patient's chief complaint.

METHODS

Focused questions

Using patient, intervention, comparison, outcome (PICO) format, the following criteria were framed for this literature search, that is P: patients with DDWR that seeks treatment for their condition due to the presence of pain and/or clicking sound; I: patients instructed to use ARS as a form of treatment for DDWR; C: comparing the position of articular disc within TMJ complex before, during and after treatment with or without the use of ARS. Pain and clicking evaluation before

and after treatment with ARS compared to without the use of ARS. Comparisons performed using MRI; O: effectiveness of ARS with the following outcome that is pain resolution, clicking sound resolution and resolution in disc position within the TMJ complex.

Search strategy method

Using electronic search of three databases, MEDLINE (Via PubMed), Cochrane Library and Scopus, was performed to identify the relevant literature. Articles that are published in the last 10 years, from January 2010 to December 2019, were considered. The following combination of keywords was applied ((ARS [All Fields] OR anterior repositioning appliance [All Fields]) AND (DDWR [All Fields] OR TMD [All Fields] OR TMJ dysfunction [All Fields] OR TMJ disease [All Fields]) AND (MRI [All Fields] OR MRI [All Fields])).

Additionally, manual search of relevant articles was performed. Articles published between the year 2010 through the latest, which is 2019, was performed in the following journals: Journal of Cranio-Maxillofacial Surgery, Journal of Oral Rehabilitation, Scientific Reports, Journal of Applied Oral Science.

Inclusion and exclusion criteria

The following inclusion criteria were applied: any case series, prospective, retrospective, cohort studies, controlled clinical trials, or randomized clinical trials with five or more patients included, full text in English, and a minimum of patient follow-up performed after treatment.

The following exclusion criteria were applied: in vitro studies and animal studies

RESULT

Using the search strategy, 14 articles from Cochrane Library, 6 articles Scopus, and 5 articles from MEDLINE via PubMed. Using the inclusion and exclusion criteria, 6 articles were selected to be part of inclusion criteria.

Article by Liu et al evaluated the effect of bite position when different splint treatments are used to a sample of 37 subject with a mean age of 18.8 $\pm$4.3 years old. Maximum intercuspation was used as control, while ARS is being compared with stabilization splint. Measurement using MRI is performed by determining the disc-condyle angle during the use of the splint. In this study it was shown that ARS improves relationship between disc condyle more than stabilization splint and control. However, it is also shown that transitory posterior movement of the disc also occurred. Here the author mentioned that as soon as ARS is no longer being used, articular disc will return to its displaced position. The long term effect of continual use of ARS is not being investigated.

Chantaracherd investigated more about the

Table 1 The 6 journals selected to be part of inclusion criteria

Author	Findings on pain resolution	Findings on clicking resolution	Findings on change in discal recapture after the use of ARS
Liu et al[5]	No information on pain	ARS resolve clicking sound, but the sound returns after no longer using ARS	Disc recapture was more significant in the use of ARS when compared to control and SA (stabilization appliance)
Chantaracherd et al[4]	Using characteristic pain intensity (CPI), ARS is statistically significant up to 3 months after treatment end	ARS use has no impact on clicking sound	No information on discal position
Ma et al[6]	Statistically significant reduction in joint pain	Statistically significant reduction in joint clicking	Disc recapture was statistically significant in younger subject (early adolescent) but not in older (late adolescent)
Litko et al[8]	Statistically significant in joint pain	No information in joint clicking, but patient with limited mouth opening show sign of improvement.	No information on disc recapture, but correlation is made between the severity of disc displacement with restriction in mouth opening.
Xie et al[7]	No pain is reported after the use of ARS	No information in joint clicking	No information in disc recapture, but in adolescent patient it shows mandibular asymmetry for patient who does not receive ARS after 6 months follow up
Chen et al[3]	Pain resolves after treatment with no recurrence	Joint clicking sound completely disappeared during observation period	Disc recapture is shown from the time of ARS use and up to 6 months post-treatment. After that period, disc recapture only appears in 40.6% of subject

conventional pathway of the progression of DDWR to disc displacement without reduction (DDWoR). The use of ARS is shown to alleviate pain in patient with DDWR, but patient without pain that do not use ARS is also shown to remain stable for years after observation. It seems that the progression of DDWR to DDWoR, as we previously believed, is not an absolute theory, because some people, especially older people, can experience DDWR without progressing to degenerative disease. Therefore, in this cross sectional studies there is not association between TMJ intra-articular status and TMD impact.

Ma et al tries to determine the efficacy of ARS in DDWR patient with class II occlusal relationship in 91 subjects with mean age of 15.7 years old. The observation was performed using MRI and images were taken before treatment (T0), after bite registration (T1), at the end of treatment (T2), and 12 months after treatment (T3). In this study it was shown that the efficacy of ARS decreases over time. However, from clinical and MRI findings it can be concluded that ARS is an effective treatment modality in DDWR, especially for patients in early puberty.

Litko et al analyses the degree of DDWR with restriction in mouth opening; 191 patients: 148 women and 43 men ages 14-60 years old, that are diagnosed with DDWR were treated and found that the severity of DDWR from sagittal is statistically significant predictor in mouth opening. The association of disc displacement and TMJ internal derangement were made in this journal, and no clicking is mentioned during the trial.

Xie et al studies how DDWR affects mandibular asymmetry in adolescent patient. In this self-control longitudinal study, craniofascial growth were recorded at least 6 months in 40 patients ages 10-20 years, and found that if DDWR is not treated, then the severity of mandibular asymmetry during growth increases. There is no mention on joint pain and clicking associated with DDWR.

The study by Chen et al examines the short and long term effect of ARS on disc condyle by metric analysis by Draze-Enazmann Disc condyle angle using MRI. 32 TMJ were studied and MRI image were taken before the study, immediately post-insertion and 6 months after treatment. The study found that ARS has a good short term effect on disc condyle complex with relatively lower efficacy in long term of 6-months observation period.

When comparing results between the articles, many heterogenities of results are shown in terms of subject choice, methods of assessment, and factors to be considered. Some articles, such as Ma et al and Xie et al uses subject ages 12-18 years old to assess the treatment of DDWR on a subject that are still undergoing growth stage. This can produce different result when compared to older subject who are no longer growing. Moreover, some subjects use questionnaire as a form of assessment in terms of improvement, such as Chantaracherd et al and Litko et al, whereas other researchers use MRI as the gold standard of TMJ assessment. These differences need to be taken into account when analyzing the results that they have.

In general, these articles have similarity in conclusion especially 1) the use of ARS is an effective modality to treat DDWR. Results is statistically significant during and post-treatment. However, after 6 months, some patients have their condition relapsed back into DDWR. Therefore longitudinal studies are needed to further assess the efficacy of ARS; 2) the lack of treatment of DDWR does not lead into further disc derangement disorder such as DDWoR or other degenerative disorder. These chains of causality must be investigated further.

DISCUSSION

Disc displacement with reduction

DDWR is known to be the most common internal derangement of TMJ condition in the majority of the population.[6] When teeth occlude, articular disc is positioned more anterior than normal, and often reduced to normal position during mouth opening. This condition is thought to be caused by biomechanical pressure that the condyle receive against mandibula, which can cause progressive change in function and form. Various factors that potentially play a role in increasing the risk of DDWR can be summed into microtrauma and macrotrauma. Macrotrauma, such as automobile accident or a physical hit to lower jaw, can be easily found out during anamnesis. Microtrauma, however, can be undetected when examined with an inexperienced clinician. One of the example of microtrauma is bruxism[2], and orthopedic instability that can happen in tooth arrangement that are unstable. It can also happen to Angle class II division two which is often found to have positive correlation with DDWR. Other condition, such as hypoxia reperfusion injury is also another form if microtrauma whereby overloading joint overtime can cause soft tissue degradation. Damage to collagen fibril causes reduction in collagen network, and secretion of synovial fluid from

articular disc creates a more tender disc. This condition is also known as chondromalacia. When this condition left untreated, articular disc adhesion can occur at the superior compartment of articular disc, which contributes to DDWR.[1]

The progress of DDWR can be explained through elongation of discal collateral ligament. Thinning of the posterior border of articular disc can also cause to displace articular disc anteriorly, which shifts condyle position to a more posterior position, closing in to retrodiscal tissue. This could potentiate into DDWR with painful symptoms due to aggravation of retrodiscal tissue. When patient opens their mouth, the motion of mouth opening cause changes in articular disc position.[2,9]

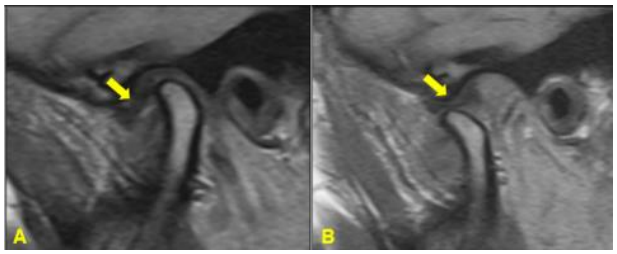

Figure 1 DDWR; **A** during maximum intercuspation, articular disc (yellow arrow) is located more anteriorly in its relation with TMJ's condyle fossa complex; **B** during maximum mouth opening position, articular disc returns to normal position, where it articulates well in between condyle and articular eminence.[2]

The prevalence of DDWR is higher among women than men. It is speculated that the joint laxity of women's joint articulation along with higher intra-articular pressure is one of few probable causes of this discrepancy when compared to men. Furthermore, there are positive correlation between an increase in age and an increase in prevalence which is thought to be caused by the change in articularis disc dimension along with advancing age.[2] Other researcher have found that an estrogen receptor within women's TMJ complex allows them to speculate that changes in metabolic function due to fluctuation in women's estrogen level can cause changes in flexibility of TMJ's ligament.[6] These findings are thought to contribute to the increasing number of women who suffers from DDWR when compared to men.

It has been suggested that DDWR would be the first stage of disc displacement, and its progress to DDWoR, retrodiscitis or other intracapsular disorder is inevitable. However, such speculations is not consistent to all conditions and types of DDWR. Researchers have found that, from the study of 155 TMJ patient with DDWR, 93.5% of them would not have this condition progresses; only 6.5% of these patients, or six TMJ, that progresses into DDWoR. The condition of DDWR can continue to remain unchanged as long as patient has an adaptive capacity to withstand clicking. The most common findings of adaptive capacity are in a form of retrodiscal fibrosis, where bilaminar zone of TMJ created fibrotic structures as an evidence of adaptive capacity of articular disc. This conditions can be stimulated through the use of occlusal splint (Fig 2).[2,6,9]

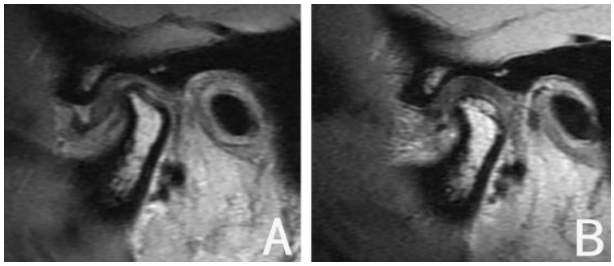

Figure 2A The condition of DDWR within TMJ complex before treatment, viewed using MRI; **B** TMJ complex after treatment with occlusal splint. Bone apposition can be seen in posterosuperior region of the condyle and the formation of retrodiscal fibrosis within the retrodiscal tissue.[6]

TMJ complex to confirm DDWR can be examined using MRI as the gold standard.[2,5,8–10] MRI can accurately show the morphology and the articular disc position in relation to the bone structures within TMJ. The specificity value is around 88-90% with sensitivity value between 78-83.3%.[2,3,5] Several techniques available to analyze articular disc position in relation to condyle and fossa. One of the more common technique is the Draze-Enazmann method. Point C is designated as the centric point within the condyle head, while Point D is the middle point within the posterior margin of posterior articular disc. Line 1 can then be created from point C and be made perpendicular to Frankfort Horizontal plane. Line 2 can be made by joining point C and D. when Line 1 and 2 are examined, the angle made between these two lines is known as disc-condyle angle. The normal value of this angle is between -15° and +15°. When the value is larger than +15°, then it is an indication of DDWR condition being positive (Fig 3).[3,5]

Ultrasonography can be used as an alternative way to examine the condition of DDWR. This technique has specificity value of 66.7% and sensitivity of 78.6%. The drawbacks of USG is the lack of standardized examination technique, so it's accuracy varies in each examination when compared to MRI.[2]

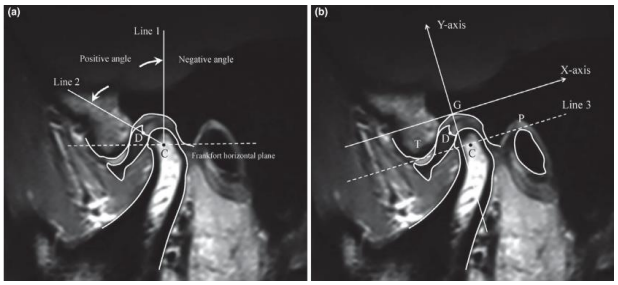

Figure 3A Examination of DDWR using MRI and Draze-Enazmann method. Point C is the centric point of the condyle head, while point D is the middle point of the posterior margin of articular disc. Line 1 can be made from point C and be made perpendicular to Frankfort Horizontal plane, while Line 2 is made by joining point C and D. between Line 1 and 2, it will create an angle known as disc-condyle angle; **B** coordinate measurement of articular disc position and condyle head.[3,5]

Aside from the advancement of technology, manual examination remains preferred examination method of choice is most TMJ dysfunction case. According to the Diagnostic Criteria for TMD (DC/TMD),[11,12] examination of DDWR must meet at least one of these criteria: 1) in the last 30 days, any TMJ noise(s) present with jaw movement or function, or 2) patient report of any noise during the exam.

During the examination, patient must experience at least one of the following: 1) clicking, popping, and/or snapping noise during both opening and closing movement, detected with palpation during at least one of three repetitions of jaw opening and closing movement, or 2) clicking, popping and/or snapping noise detected with palpation during at least one of three repetition of opening or closing movement, and 3) clicking, popping, and/or snapping noise detected with palpation during at least one of three repetition of right or left lateral, or protrusive movement(s).

The use of imaging is the reference standard for this diagnosis. The use of panoramic imaging provides 34% sensitivity value and 92% specificity value.[11,12] However, other research found that the methode proposed using DC/TMD only provides 44% sensitivity value and 46-57% specificity value in evaluating DDWR.[2]

According to Jeffrey Okeson, DDWR should have the following criteria: 1) there is a single joint sound during opening and closing movement in one or both TMJ. Joint sound does not include reciprocal sound or crepitation sound; 2) can have association with joint pain; 3) normal mandibular motion, with maximum mouth opening more than 40 mm when measured from incisal edge of upper central incisive against lower central incisive tooth.

Anterior repositioning splint

Fabrication of ARS was first proposed by Farrar in 1970.[3] The purpose of ARS is to return association between disc-condyle-fossa complex into normal position. When mandible is positioned more anterior dan maximum intercuspation (MI) by using ARS, this provides stability to TMJ. The use of reverse incline on ARS in the anterior maxillary region will provide guidance to occlude in a more anterior position (Fig 4).[6]

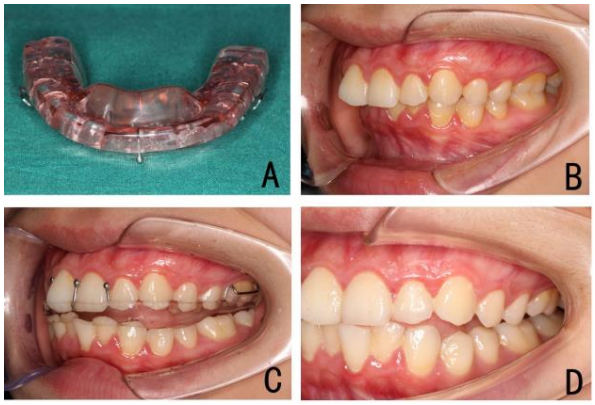

Figure 4A Full coverage ARS on anterior maxilla using the reverse incline plane bite block on palatal as guidance so that mandibula can be positioned more anterior; **B-D** occlusal re-establishment after the use of ARS. [6]

The treatment mechanism of ARS as a mode of therapy is still debatable. Two theories emerge that are generally acceptable among researcher. One of them is the '*recapturer*' theory who stipulates that as condyle is placed more anteriorly, the relationship between disc-condyle-fossa allows articular disc to recapture a normal relationship by guiding condyle to occlude along the posterior slope of articular eminence through periodic modification of ARS. With repeated use for short period of time, articular disc can stimulate bone apposition along the posterosuperior area of condyle and/or creating fibrotic structures along the retrodiscal tissue (figure 5).[3,6,9] Another theory proposes that after the use of ARS, clinician must restore the whole dentition so that mandibula will return to therapeutic position, which is a position that locates condyle more anteriorly. This is known as the '*rebuilders*'.[3] Okeson stated that the '*recapturer*' theory is more acceptable because fibrotic structure along the retrodiscal tissue can remove pain symptoms that is associated with DDWR. Furthermore, mandibular position would be able to return back into a musculoskeletally stable position, when compared to rebuilders that maintains therapeutic position more anterior than muskuloskeletally stable position.[1,9]

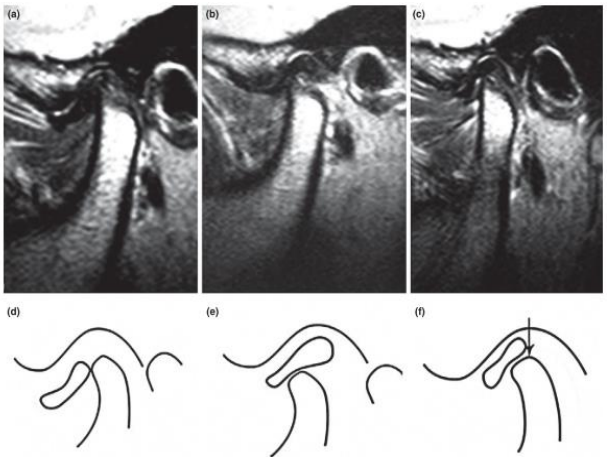

Figure 5 (A) DDWR before treatment. (B) DDWR after placement of ARS, where articular disc is recaptured to a more normal position in maximum intercuspation where loading of the joint is transferred within the thin intermediate zone between condyle and fossa. (C) Fibrotic structure is made as an adaptive response to the use of ARS after 6-8 weeks. Retrodiscal tissue does not elicit joint pain because of its fibrotic structure. (D-F) A diagrammatic representation of A-C, respectively.[3]

Primary indication of the use of ARS is to treat DDWR as well as disc displacement with intermittent locking on mandibula. The use of ARS has also been shown to be able to treat single clicking or reciprocal clicking joint that can be accompanied with pain. Patient with retrodiscitis can find some relief using ARS.

ARS commonly use hard acrylic and adapted on one of the jaws, usually the maxilla. Maxilla is the preferred choice because it is easier to make reverse incline ramp on a more stable occlusal surface when compared to mandible which is more mobile. A 2 mm thickness is often enough to provide an adequate strength to the appliance. The incline ramp will guide mandible to a more anterior position. Appliance will be used and its efficacy will be evaluated. If symptoms do not improve, then patient's condition will be re-evaluated.

When ARS fails to relieve symptom, there is a possibility that the etiologic factor has not been addressed. Pain can come from TMJ complex, or better known as intracapsular pain, or it can also come from muscle, also known as intercapsular pain or myogenous pain. When pain comes from muscle, then symptom relieve can progress slowly, because of protective co-contraction muscle response that can cause uncomfortable muscle tension which can sensitize joint. Repeating diagnostic procedure becomes important for clinician to be able to better determine etiologic factor of each individual patient.[1,9]

Success rates is one factor that needs to be considered to determine the efficacy of the use of ARS. According to Okeson, joint sound cannot be the determining factor of ARS's success, because long term studies have indicated that more than 50% of patients after ARS treatment will have returning joint sound. Moreover, when factors that determine success includes the reduction of joint sound and pain resolution, the success rate of ARS treatment is only 28%. However, if we modify the factors to only the resolution of pain, then the success rate increases into 75% over an observation period of 2.5-5 years.[13] Joint sound has been found to be more resistant to repair when compared to pain resolution after the use of ARS.

The use of MRI has become the golden standard to evaluate articular disc position prior, during and after the insertion of ARS. This observation is to help us determine whether joint sound can become the cause of DDWoR. The findings are summarized on table 1, and it can be concluded that ARS can become a viable treatment on joint pain to patients with DDWR, and joint sound does not determine the failure of ARS treatment; only 6% of patient with joint pain and DDWR that progresses into other internal derangement condition such as DDWoR or joint locking.[1–3,9] the use of ARS gives opportunity for retrodiscal tissue to adapt and form fibrotic structure to allow TMJ to function without joint pain while maintaining a more anterior positioned articular disc.

The use of ARS should meet the following criteria during insertion: 1) ARS must adapt well with the corresponding natural teeth so that retention and stabilization of splint can be maintained well. Retention should be examined by palpating the splint in patient's mouth; 2) in a protruded mandible position, all mandibular teeth must contact evenly, where mandibular cusp have some contact with the occlusal surface of ARS; 3) the protruded position that is made from the splint must resolve symptoms during opening and closing of mouth at the new position; 4) during retruded mandible position, reverse incline ramp must contact the opposing teeth. As mandible elevates, splint must guide mandible to therapeutic mandibular position; 5) ARS must be polished to have an even surface.

Post-insertion instruction varies among researcher; some pointed out that the use of ARS should be use for 24 hours, and only removed during eating and brushing teeth. Ma *et al* recommend creating a 5 mm thick ARS to remove reciprocal clicking, where occlusal grinding was per-

formed to reduce ARS thickness 1 mm for every 4-6 weeks in the posterior region to induce vertical eruption of patient's teeth and achieve occlusal plane levelling. Patient will use ARS for 1-3 months, and deemed successful when joint clicking and pain did not return after 1-3 months post-treatment.[6] According to Chen *et* al, the use of ARS should have at least 3 months of use for 24 hours, and continues by wearing ARS only at nighttime.[3]

Okeson suggest that the use of ARS should be limited on nighttime only. Daytime use reserves to condition where patient cannot tolerate joint pain during working hours, and the use is limited to resolving the pain only. When the pain resolves, the use of ARS should be discouraged, as to prevent changing mandible's position more anteriorly. In addition, patients were instructed with physical self-regulation (PSR) regimen to aid in TMJ treatment. The goal of PSR is to make patient conscious of their condition, also known as cognitive awareness, in terms of spatial position of their mandible so that patient can reduce non-functional contact and excessive muscle activity actively to aid in TMD joint pain management. PSR involves proprioceptive practice and relaxation techniques.[9]

Treatment becomes tricky when patient's main complaint is a very loud joint sound. For the majority of patients, patient's education is the treatment of choice. There is no standardized treatment of TMJ joint sound, so healthcare practitioner must perform conservative treatment as treatment of choice through education, PSR, occlusal splint, and muscle exercises of the jaw. Invasive treatment is rarely indicated during DDWR because of the many risk associated with invasive surgical procedure.

When the use of ARS does not improve pain tolerance, healthcare workers need to consider two possibilities. One is that the adaptive process of retrodiscal tissue in inadequate in creating fibrotic structure to allow this tissue withstand functional load. In this case, the use of ARS must be lengthened to provide opportunity for the structure to adapt. However, if pain is caused by orthopedic instability, then patient may have returning symptoms after treatment with ARS. In this case, dental treatment needs to be administered so as to attain orthopedic stability. The treatment is seldom needed, however.

Invasive treatment can be considered when conservative treatment did not produce the intended result. Persistence of symptoms is one sign that indicates failure of ARS addressing the problem. Treatment options that can be considered are arthrocentesis, arthroscopy and surgical treatment. Arthrocentesis is a treatment of injecting therapeutic substance such as hyaluronate acid or corticosteroid with the intention to flush away algogenic substance that adheres in the articular disc, notable the superior joint space of the articular disc. Furthermore, the procedure also modifies intracranial pressure, which relieves pain. The use of arthrocentesis is indicated with closed lock TMJ, rheumatoid arthritis or adhesion. The use of arthrocentesis for DDWR is seldom indicated.[14] Arthroscopy treatment uses arthroscope to directly observe superior joint space so as to identify and eliminate adhesion on joint. However, invasive treatment often is accompanied with elevated risk, such as extravasation of synovial fluid, facial nerve lesion, eye lesion, pre-auricular hematoma, intracranial perforation, and other risks. These risks needs to be addressed so that patient can receive for benefit having this treatment performed that the risk.[9]

It was concluded that the purpose of the treatment of DDWR should be to reduce intracapsular pain, and not necessarily returning articular disc position to a normal position. The use of ARS is another non-invasive treatment modality that can be offered to DDWR's patient so that the use of ARS will allow adaptive response by eliciting fibrotic structure on retrodiscal fossa and returning articular disc to a more normal position of disc-condyle-fossa. Variation exist regarding the post-treatment instruction, but most afree that the use of ARS should only be on a short-term basis to reduce the risk of a more permanent unintended occlusal change. Adaptive response occurs between 8-10 weeks, and most patients experience relieve of pain. The lack of gold standard for the treatment of DDWR prompts healthcare provider to opt for conservative treatment before considering advancing to a more invasive procedure.

REFERENCES

1. Okeson JP. Joint Intracapsular Disorders: Diagnostic and Nonsurgical Management Considerations. Dent Clin North Am. 2007;51(1):85-103.
2. Poluha RL, De La Torre Canales G, Costa YM, Grossmann E, Bonjardim LR, Conti PCR. Temporomandibular joint disc displacement with reduction: A review of mechanisms and clinical presentation. J Appl Oral Sci. 2019;27:1-9.
3. Chen HM, Liu MQ, Yap AUJ, Fu KY. Physiological effects of anterior repositioning splint on

temporomandibular joint disc displacement: a quantitative analysis. J Oral Rehabil. 2017;44(9):664-672.
4. Chantaracherd P, John MT, Hodges JS, Schiffman EL. Temporomandibular joint disorders' impact on pain, function, and disability. J Dent Res. 2015;94(3):79S-86S.
5. Liu MQ, Lei J, Han JH, Yap AUJ, Fu KY. Metrical analysis of disc-condyle relation with different splint treatment positions in patients with TMJ disc displacement. J Appl Oral Sci. 2017;25(5):483-489.
6. Ma Z, Xie Q, Yang C, Zhang S, Shen Y, Abdelrehem A. Can anterior repositioning splint effectively treat temporomandibular joint disc displacement? Sci Rep. 2019;9(1):8-15.
7. Xie Q, Yang C, He D, et al. Will unilateral temporomandibular joint anterior disc displacement in teenagers lead to asymmetry of condyle and mandible ? A longitudinal study. J Cranio-Maxillofacial Surg. 2016;44(5):590-596.
8. Litko M, Berger M, Szkutnik J, Różyło-Kalinowska I. Correlation between direction and severity of temporomandibular joint disc displacement and reduction ability during mouth opening. J Oral Rehabil. 2017;44(12):957-963.
9. Okeson JP. Management of Temporomandibular Disorders and Occlusion 8th Edition. 8th ed. Missouri: Elsevier Inc; 2020.
10. Kumar Rg, Gajapathi B, Ibrahim Mm, Karthik P, Rangarajan V, Yogesh P. Concepts of occlusion in prosthodontics: A literature review, part I. J Indian Prosthodont Soc. 2016;15(3):200.
11. Schiffman E, Look J, Anderson G, et al. DC/TMD for clinical and research application. 2014;28(1):6-27.
12. Okeson JP. Reliability and validity of the DC/TMD Axis I. J Oral Facial Pain Headache. 2018;32(1):19-21.
13. Okeson JP. long term treatment of disk interference disorders of the temporomandibular joint with anterior repositioning occlusal splints. :611-616.
14. Monje-Gil F, Nitzan D, González-Garcia R. Temporomandibular joint arthrocentesis. Review of the literature. Med Oral Patol Oral Cir Bucal. 2012;17(4).