Long-Term Outcome of Arthrocentesis Plus Hyaluronic Acid Injection in Patients With Wilkes Stage II and III Temporomandibular Joint Internal Derangement

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Objective: Arthrocentesis is a minimally invasive procedure used to manage temporomandibular joint (TMJ) internal derangement (ID). This study evaluated the outcome of arthrocentesis in patients with Wilkes stage II and III TMJ ID.

Patients and Methods: This retrospective study enrolled 50 patients who underwent arthrocentesis in 2011 and 2012 at the Karadeniz Technical University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, Turkey. In total, 43 patients underwent unilateral arthrocentesis, whereas 7 patients had bilateral arthrocentesis. The clinical parameters recorded were pain (visual analogue scale [VAS] 0–100 mm during movement), chewing function efficacy (VAS 0–100), clicking sounds, and mandibular movements, including maximum interincisal opening (MIO), lateral excursion, and protrusion. All the parameters were recorded preoperatively, and 1, 3, 6, and 24 months after treatment.

Results: The MIO, lateral excursion, and protrusion were significantly greater than preoperatively in all the patients. Pain declined significantly postoperatively. The patients in Wilkes III group had greater improvement in mandibular movement and pain than the patients in Wilkes II group.

Conclusion : Arthrocentesis was reliable for treating both Wilkes II and III TMJ ID, and the treatment results were better in Wilkes III patients.

Key Words: Lavage, pain, temporomandibular joint disorders

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Internal derangement (ID) of the temporomandibular joint (TMJ) is defined as a disturbance of the normal relationships of the articular disc, mandibular condyle, and articular eminence.[1] The severity of ID is evaluated using the Wilkes classification, which consists of 5 stages ranging from symptom-free slight forward displacement to degenerative arthritic changes along with severe symptoms (Table 1).[2] Pain on mandibular functions causes restricted jaw movements and dysfunction, as frequently reported by patients with ID.[3,4] The treatment alternatives in ID range from surgical interventions such as disc repositioning, discectomy, and modified condylotomy to noninvasive treatments such as arthrocentesis and arthroscopic lysis and lavage.[5–9]

Arthrocentesis of the TMJ, first reported by Nitzan et al[10] as a minimally invasive and effective method for managing closed-lock TMJ, involves flushing out the superior joint space through needles.[10,11] When initial conservative measures such as a soft diet, physical therapy, and occlusal splint therapy fail to manage the TMJ pain and dysfunction, arthrocentesis is an efficient procedure with low morbidity.[12] The reduction in pain and dysfunction is believed to result from removal of the accumulated inflammatory mediators in the joint.[13] After infiltrating local anesthesia in the superior joint space and overlying skin, Ringer's lactate solution or physiological saline is typically used to wash the joint space.[14] Although arthrocentesis was originally proposed for managing painful closed lock of the TMJ, it also has therapeutic effects in various stages of ID of the TMJ.[15,16] Although stage IV or V ID might require open joint surgery, earlier stages can be managed with minimally invasive arthrocentesis before resorting to arthroscopic or open TMJ surgery. Smolka et al[17] reported that the success rates of arthroscopic surgery were lower in advanced Wilkes stages. Another study found that arthroscopic lysis and lavage were less successful in patients with advanced ID than in patients with earlier stages of ID.[17]

Hyaluronic acid (HA) injection after arthrocentesis of TMJ has been proposed because of its effectiveness for joint stabilization, joint space nutrition, and restoring normal lubrication.[18,19] Hyaluronic acid injection decreases the symptoms resulting from ID. Arthrocentesis is effective for Wilkes stage I and II, whereas the evidence for recommending arthrocentesis in stage III patients is inconclusive.[20] This study was based on the hypothesis that HA injection following arthrocentesis can have varying outcomes in different stages of TMJ ID, and the study evaluated the efficacy of arthrocentesis in patients with Wilkes stage II or III TMJ ID.

METHODS

Study Design

This retrospective analysis enrolled 62 patients who presented with symptoms of TMJ disorders (TMDs), and who underwent arthrocentesis at the Department of Oral and Maxillofacial Surgery between March 2011 and July 2013. The inclusion and exclusion criteria were as follows:

Inclusion criteria

- pain in the TMJ during mandibular movements and function;
- patients with Wilkes stage II or III TMD;
- failure of conservative treatment, like medical or splint therapy; and
- persisting pain despite the injection of local anesthetic to eliminate myofascial pain.[21]

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TABLE 1. Clinical and Radiological Criteria for the Wilkes Staging of Temporomandibular Joint Internal Derangement

Stage	Clinical Findings	Radiological Findings
I	No significant mechanical symptoms, no pain or limitation of motion	Slight forward displacement and good anatomic contour of disc
II	First few episodes of pain, occasional joint tenderness and related temporal headaches, increase in intensity of clicking, joint sounds later in opening movement, beginning transient subluxations or joint locking	Slight forward displacement and beginning anatomic deformity of disc, slight thickening of posterior edge of disc
III	Multiple episodes of pain, joint tenderness, temporal headaches, locking, closed locks, restriction of motion, difficulty (pain) with function	Anterior displacement with significant anatomic deformity/prolapse of disc, moderate to marked thickening of posterior edge of disk, no hard tissue changes
IV	Chronicity with variable and episodic pain, headaches, variable restriction of motion, and undulating course	Increase in severity over intermediate stage, early to moderate degenerative remodeling, hard tissue changes
V	Crepitus on examination, scraping, grating, grinding symptoms, variable and episodic pain, chronic restriction of motion, difficulty with function	Gross anatomic deformity of disc and hard tissue, essentially degenerative arthritic changes, osteophytic deformity, subcortical cystic formation

Exclusion criteria

- systemic rheumatic disease;
- lost to regular follow-up;
- previous open TMJ surgery; and
- use of any anti-inflammatory or muscle relaxing medications.

The maximum interincisal opening (MIO), lateral excursion, and protrusion; pain score (visual analogue scale [VAS] 0 = no pain, 100 = worst pain ever); clicking/crepitation (0 = no sound, 1 = mild sound, 2 = severe sound); and chewing function efficacy (VAS 0 = no function, 100 = complete function) were recorded preoperatively, 1 week postoperatively, and at the last follow-up. Arthrocentesis was performed in 7 patients bilaterally and in 43 patients unilaterally. The procedure was performed once in 43 patients and twice in 7 patients who did not have sufficient reduction of symptoms after the first session.

Any medication (anti-inflammatory medicine or muscle relaxants) was not prescribed to the patients after our treatment protocol.

All the patients signed written informed consent. The tenets of the World Medical Association Declaration of Helsinki were followed. The regional ethics review board of Karadeniz Technical University approved this study.

Arthrocentesis Procedure

After cleaning the skin with povidone iodine, the insertion points of the needles were marked on the skin, as described by Nitzan et al.[22] A line was drawn from the midline of the tragus to the lateral canthus. The first needle was inserted 10 mm anterior to the tragus and 2 mm below the line. The second point was marked 10 mm anterior to the first point and 10 mm below the line. Local anesthetic (4% articaine hydrochloride with 1:200,000 epinephrine) was injected into the superior joint space and overlying tissues by gently withdrawing the needle. Two 21-gauge needles were used for the arthrocentesis procedure. A minimum of 250 mL Ringer's lactate solution was used for irrigation and 1 mL high molecular weight HA (ORTHOVISC; Anika Therapeutics, MA) was injected into the superior joint space through the posteriorly positioned needle (Fig. 1). Patients were instructed on physical therapy that consisted of motion exercises 10 times daily, the use of muscle relaxants and anti-inflammatory agents, and a soft diet for 10 days postoperatively.

Statistical Analysis

The statistical analyses were performed with SPSS for Windows 15.0. Time-dependent differences were analyzed with the Friedman test, and if needed, the Wilcoxon signed-rank test with the Bonferroni correction ($P < 0.017$) for the MIO, right and left excursion, protrusive movements, clicking/crepitation, and VAS scores for pain and chewing efficacy. Time-dependent differences in the VAS scores were evaluated with the Wilcoxon signed-rank test ($P < 0.05$). To compare the Wilkes classification (groups II–III) for each parameter, the Mann-Whitney test was used ($P < 0.05$).

RESULTS

Of these, 12 patients were excluded because of the missing follow-up periods, leaving 50 patients who met the inclusion criteria and were enrolled in the study. Fifty patients (11 male and 39 female) were evaluated, and the mean patient age was 33.04 (range 16–72) years. The mean follow-up period was 19.63 ± 5.2 (range 6–24) months. Preoperatively, 21 patients had Wilkes stage III ID, whereas 29 patients had Wilkes stage II ID.



FIGURE 1. Hyaluronic acid injection into the superior joint space.

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Maximum Interincisal Opening

For the Wilkes II patients, the mean preoperative MIO was 40.62 ± 5.6 (range 30–52) mm and it was 41 ± 4.5 (range 33–50) mm at the last follow-up (Table 2). For the Wilkes III patients, the MIO changed from 28.95 ± 9.2 (range 4–46) mm preoperatively to 35.9 ± 5.2 (range 27–47) mm at the last follow-up (Table 3). The increase in the MIO in the Wilkes III patients was significant ($P < 0.01$), whereas that in the Wilkes II patients was not significant ($P = 0.08$).

Lateral Excursion

The increase in left lateral excursion between preoperatively and the last follow-up was significant in both Wilkes II ($P = 0.001$) and III ($P = 0.011$) patients, whereas the change in right lateral excursion was not significant in either Wilkes II ($P = 0.051$) or III ($P = 0.097$) patients.

Protrusive Movements

Protrusive movements were significantly increased 1 week postoperatively in both Wilkes II ($P < 0.01$) and III ($P = 0.004$) patients, and persisted at the last follow-up.

Visual Analogue Scale Scores for Pain

The preoperative VAS scores for pain were higher in the Wilkes III patients than in Wilkes II patients, which concur with the advanced stage of the disorder in Wilkes III patients ($P < 0.01$). Significant reductions in the VAS scores for pain were recorded at the last follow-up examination in both groups ($P < 0.01$).

Clicking/Crepitation

The clicking/crepitation scores diminished significantly from preoperatively to the last follow-up in both Wilkes II ($P < 0.01$) and III ($P = 0.002$) patients.

TABLE 2. Descriptive Statistics of the Wilkes II Patients

	Number	Minimum	Maximum	Mean	Standard Deviation
MIOPRE	29	30	52	40.62^{A}	5.634
MIO1 w	29	30	50	40.31^{A}	5.204
MIOLAST	29	33	50	41.00^{A}	4.520
LEFTPRE	29	2	12	6.69^{A}	2.661
LEFT1 w	29	4	12	7.72^{A}	2.313
LEFTLAST	29	5	12	8.07^{C}	2.069
RIGHTPRE	29	3	12	6.66^{A}	2.907
RIGHT1 w	29	4	11	7.52^{A}	2.230
RIGHTLAST	29	5	11	7.66^{A}	1.857
PROTPRE	29	2	10	4.69^{B}	1.929
PROT1 w	29	3	11	6.00^{A}	2.104
PROTLAST	29	3	11	6.38^{A}	1.840
VASPRE	29	25	100	55.86^{A}	16.801
VAS1 w	29	20	80	48.78^{A}	15.857
VASLAST	29	20	60	34.14^{B}	10.528

In the column for each individual parameters, values with different superscript letters indicate significant differences ($^{B}P < 0.01$, $^{C}P < 0.001$), whereas same letters indicate no significant differences ($^{A}P < 0.01$). Left, left exurcision; MIO, maximum interincisal opening; Pre, preoperative; Right, right exurcision; Prot, protrusive; VAS, visual analogue scale.

TABLE 3. Descriptive Statistics of the Wilkes III Patients

	Number	Minimum	Maximum	Mean	Standard Deviation
MIOPRE	21	4	46	28.95^{B}	9.282
MIO1 w	21	25	48	35.19^{B}	6.080
MIOLAST	21	27	47	35.90^{B}	5.272
LEFTPRE	21	1	13	5.67^{B}	3.411
LEFT1 w	21	4	11	6.95^{B}	2.037
LEFTLAST	21	5	10	7.29^{B}	1.586
RIGHTPRE	21	1	10	6.43^{A}	3.043
RIGHT1 w	21	4	11	7.33^{A}	2.153
RIGHTLAST	21	4	10	7.57^{A}	2.014
PROTPRE	21	1	10	3.76^{C}	1.895
PROT1 w	21	4	9	4.95^{C}	1.322
PROTLAST	21	3	8	5.33^{C}	1.278
VASPRE	21	40	100	74.52^{B}	16.651
VAS1 w	21	30	90	43.06^{B}	15.254
VASLAST	21	20	90	39.05^{B}	14.800

In the column for each individual parameters, values with different superscript letters indicate significant differences ($^{B}P < 0.01$, $^{C}P < 0.005$), whereas same letters indicate no significant differences ($^{A}P < 0.01$). Left, left exurcision; MIO, maximum interincisal opening; Pre, preoperative; Right, right exurcision; Prot, protrusive; VAS, visual analogue scale.

Visual Analogue Scale Scores for Chewing Function Efficacy

Another parameter that changed significantly between preoperatively and the last follow-up evaluation in both the Wilkes II ($P = 0.000$) and III ($P < 0.01$) groups was the chewing function efficacy score. The mean score was 35.5 ± 0.57 preoperatively and 63.5 ± 27.02 at the last follow-up.

DISCUSSION

Noninvasive treatment methods such as manipulation of the mandible, splint therapy, and physical therapy are the initial treatment alternatives in the management of temporomandibular disorders (TMDs).[23,24] When these methods fail, arthrocentesis can effectively reduce pain and related symptoms.[11,25] Arthrocentesis and arthroscopy of the TMJ are less invasive procedures than open joint surgery; neither of these 2 procedures is clearly better than the other.[26] Fridrich et al[26] stated that arthrocentesis is a treatment modality between nonsurgical treatment and arthroscopic surgery. Although first proposed by Nitzan et al[10] for the treatment of closed lock of the TMJ with pain, arthrocentesis is now commonly used in the management of ID at various stages, as well as for reducing the symptoms of patients with severe TMDs before surgical intervention.[11,22,27]

Iinternal derangements comprise the most common TMDs, and the severity of ID is classified according to the classification proposed by Wilkes in 1989.[2,28] Bronstein et al[29] claimed that the more advanced the ID stage is, the more severe are the symptoms, such as joint pain and limited range of mouth opening. Another study showed that patients presenting with advanced stage ID, such as Wilkes stage IV and V, are candidates for more invasive treatment methods, such as arthroscopic surgery or open TMJ surgery.[6] Often, Wilkes II and III disease is an indication for TMJ surgery, although the aim of the operation is to preserve the disc. Bronstein and Merrill[29] reported higher success rates of arthroscopic surgery in less advanced Wilkes stage patients. Conversely, Quinn et al[30] found no statistical difference in the efficacy of arthroscopic surgery among stage III, IV, and V patients. Our

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results demonstrated a significant improvement with arthrocentesis in Wilkes III patients in terms of pain relief, MIO, and chewing efficacy. Wilkes II patients also showed improvement in all the parameters, except MIO, which was already reasonable preoperatively, and did not change significantly after arthrocentesis because of the less severe clinical status in Wilkes II patients.

In this study, TMJ pain on function was the most common symptom in both the Wilkes stage II and III patients; by the end of the study, the pain levels significantly declined in both patient groups. The exact mechanism of the decrease in pain is still not fully understood. However, a reduction in inflammatory mediators in synovial fluid, which has no blood supply, and the elimination of the negative intraarticular pressure, which is called the vacuum effect and commonly causes obstruction of the disc mechanically, are proposed as responsible mechanisms.[30] Once pain is relieved by arthrocentesis, the reduced MIO and altered mandibular movements can also improve by breaking the cycle.[31] Hyaluronic acid injection was applied once after all arthrocentesis procedures based on the literature data available on the efficacy of intraarticular HA injections in patients with disc displacement with reduction and with disc displacement without reduction.[32,33] In addition, some studies in the literature indicate that application of intraarticular HA decreases friction in abraded cartilage surfaces.[34] Conversely, some other studies in the literature have indicated no significant difference was found between with and without using HA.[15] In this study, Wilkes III patients of the current study had preoperatively less MIO than Wilkes II patients which might be owing to mechanical restrictions because of deformed or prolapsed disc. The potential beneficial effect of injection of HA on cartilaginous structures can be the possible explanatory mechanism of postoperatively increased maximum mouth opening especially in Wilkes III patients along with the breakdown of the cycle comprised TMJ pain, dysfunction, and movement restriction. In addition, the decrease in clicking/crepitation sound in both groups might be associated with the smooth movement of condyle, and/or increased range of condylar translation by the aid of lubricant effect of HA. In addition, HA injection offers the advantage of achieving TMJ stabilization and joint surface nutrition.[35,36] Guarda-Nardini et al[37] applied 1 mL of HA injection following arthrocentesis once a week for 5 weeks in patients with TMJ osteoarthritis and evaluated the short-term outcomes of this procedure. At the end of 3 months follow-up period, a cycle of 5 weekly arthrocenteses followed by HA injection was presented to be effective in the management of symptoms related to degenerative TMJ disease. In addition to the promising results of HA injection at short term, long-term evaluations present similar results. Guarda-Nardini et al applied 5 sessions of weekly arthrocenteses followed by HA injection to the 76 patients with TMJ osteoarthritis and followed up the patients at postoperative 1 week and 1 month, 3 months, and 6 months.[38] The study results exhibited that significant improvement in masticatory efficiency and decrease in pain at mastication was achieved in short term, and maintained at sixth month postoperatively. Another study by Guarda-Nardini et al has focused on 1-year evaluation of the patients who present degenerative joint disease and underwent arthrocentesis and HA injection, and it has been concluded that short-term improvements in the symptoms of TMJ osteoarthritis are maintained at the end of 1-year follow-up.[38] The positive outcomes of our study were in accordance with studies performed by Guarda-Nardini et al and Manfredini et al in which the positive outcomes achieved short term and lasted long term.[19,37,38] In a study concerning joint sounds, it has been shown that joints with reciprocal clicking indicate disc displacement with reduction, and silent and crepitating joints indicate disc displacement without reduction.[39] On the contrary, it has been advocated by Roberts et al[40] that joint clicking is not an obligatory sign of a reducing disc. In either case, both Wilkes II and III patients of the current study were mostly free of joint sounds in the last follow-up session.

CONCLUSION

Arthrocentesis plus HA injection in Wilkes II and III patients gave promising results by reducing pain and improving the mandibular movements, TMJ pain, dysfunction, and restriction of movement.

REFERENCES

1. Marguelles-Bonnet RE, Carpentier P, Yung JP, et al. Clinical diagnosis compared with findings of magnetic resonance imaging in 242 patients with internal derangement of the TMJ. *J Orofac Pain* 1995;9:244–253
2. Wilkes CH. Internal derangements of the temporomandibular joint. Pathological variations. *Arch Otolaryngol Head Neck Surg* 1989;115:469–477
3. Guarda-Nardini L, Ferronato G, Manfredini D. Two-needle vs. single-needle technique for TMJ arthrocentesis plus hyaluronic acid injections: a comparative trial over a six-month follow up. *Int J Oral Maxillofac Surg* 2012;41:506–513
4. Paesani DWP, Hatala M, Tallents RH, et al. Prevalence of temporomandibular joint internal derangement in patients with craniomandibular disorders. *Am J Orthod Dentofacial Orthop* 1992;101:41–47
5. McCarty WL, Farrar WB. Surgery for internal derangements of the temporomandibular joint. *J Prosthet Dent* 1979;42:191–196
6. Miloro M, Henriksen B. Discectomy as the primary surgical option for internal derangement of the temporomandibular joint. *J Oral Maxillofac Surg* 2010;68:782–789
7. Hall HD, Nickerson JW Jr, McKenna SJ. Modified condylotomy for treatment of the painful temporomandibular joint with a reducing disc. *J Oral Maxillofac Surg* 1993;51:133–142
8. Nitzan DW, Dolwick MF, Heft MW. Arthroscopic lavage and lysis of the temporomandibular joint: a change in perspective. *J Oral Maxillofac Surg* 1990;48:798–801
9. Stein JI. TMJ arthrocentesis. A conservative surgical alternative. *N Y State Dent J* 1995;61:68–76
10. Nitzan DW, Samson B, Better H. Long-term outcome of arthrocentesis for sudden-onset, persistent, severe closed lock of the temporomandibular joint. *J Oral Maxillofac Surg* 1997;55:151–157
11. Dimitroulis G, Dolwick MF, Martinez A. Temporomandibular joint arthrocentesis and lavage for the treatment of closed lock: a follow-up study. *Br J Oral Maxillofac Surg* 1995;33:23–26
12. Al-Belasy FA, Dolwick MF. Arthrocentesis for the treatment of temporomandibular joint closed lock: a review article. *Int J Oral Maxillofac Surg* 2007;36:773–782
13. Machon V, Hirjak D, Lukas J. Therapy of the osteoarthritis of the temporomandibular joint. *J Craniomaxillofac Surg* 2011;39:127–130
14. Sanroman JF. Closed lock (MRI fixed disc): a comparison of arthrocentesis and arthroscopy. *Int J Oral Maxillofac Surg* 2004;33:344–348
15. Alpaslan GH, Alpaslan C. Efficacy of temporomandibular joint arthrocentesis with and without injection of sodium hyaluronate in treatment of internal derangements. *J Oral Maxillofac Surg* 2001;59:613–618
16. Nishimura M, Segami N, Kaneyama K, et al. Prognostic factors in arthrocentesis of the temporomandibular joint: evaluation of 100 patients with internal derangement. *J Oral Maxillofac Surg* 2001;59:874–877
17. Smolka W, Iizuka T. Arthroscopic lysis and lavage in different stages of internal derangement of the temporomandibular joint: correlation of preoperative staging to arthroscopic findings and treatment outcome. *J Oral Maxillofac Surg* 2005;63:471–478
18. Fader KW, Grummons DC, Maijer R, et al. Pressurized infusion of sodium hyaluronate for closed lock of the temporomandibular joint. Part I: a case study. *Cranio* 1993;11:68–72
19. Manfredini D, Bonnini S, Arboretti R, et al. Temporomandibular joint osteoarthritis: an open label trial of 76 patients treated with arthrocentesis plus hyaluronic acid injections. *Int J Oral Maxillofac Surg* 2009;38:827–834

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20. Boudewijn S. *Management of Temporomandibular Joint Degenerative Diseases: Biologic Basis and Treatment Outcome*. New York, NY: Springer; 1996.
21. Tjakkes GH, Tenvergert EM, de Bont LG, et al. The effect of intra-articular injection of ultracain in the temporomandibular joint in patients with preauricular pain: a randomized prospective double-blind placebo-controlled crossover study. *Clin J Pain* 2007;23:233–236
22. Nitzan DW, Dolwick MF, Martinez GA. Temporomandibular joint arthrocentesis: a simplified treatment for severe, limited mouth opening. *J Oral Maxillofac Surg* 1991;49:1163–1167
23. Tanaka E, Kikuchi K, Sasaki A, et al. An adult case of TMJ osteoarthrosis treated with splint therapy and the subsequent orthodontic occlusal reconstruction: adaptive change of the condyle during the treatment. *Am J Orthod Dentofacial Orthop* 2000;118:566–571
24. Dolwick MF. The role of temporomandibular joint surgery in the treatment of patients with internal derangement. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1997;83:150–155
25. Hosaka H, Murakami K, Goto K, et al. Outcome of arthrocentesis for temporomandibular joint with closed lock at 3 years follow-up. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1996;82:501–504
26. Fridrich KL, Wise JM, Zeitler DL. Prospective comparison of arthroscopy and arthrocentesis for temporomandibular joint disorders. *J Oral Maxillofac Surg* 1996;54:816–820
27. Israel HA, Langevin CJ, Singer MD, et al. The relationship between temporomandibular joint synovitis and adhesions: pathogenic mechanisms and clinical implications for surgical management. *J Oral Maxillofac Surg* 2006;64:1066–1074
28. Emshoff R, Rudisch A. Temporomandibular joint internal derangement and osteoarthrosis: are effusion and bone marrow edema prognostic indicators for arthrocentesis and hydraulic distention? *J Oral Maxillofac Surg* 2007;65:66–73
29. Bronstein SLMR, Merrill RG. Clinical staging for TMJ internal derangement: application to arthroscopy. *J Craniomandib Disord* 1992:7–15
30. Quinn JH, Bazan NG. Identification of prostaglandin E2 and leukotriene B4 in the synovial fluid of painful, dysfunctional temporomandibular joints. *J Oral Maxillofac Surg* 1990;48:968–971
31. Carvajal WA, Laskin DM. Long-term evaluation of arthrocentesis for the treatment of internal derangements of the temporomandibular joint. *J Oral Maxillofac Surg* 2000;58:852–855
32. Hepguler S, Akkoc YS, Pehlivan M, et al. The efficacy of intra-articular sodium hyaluronate in patients with reducing displaced disc of the temporomandibular joint. *J Oral Rehabil* 2002;29:80–86
33. Sato S, Ohta M, Ohki H, et al. Effect of lavage with injection of sodium hyaluronate for patients with nonreducing disk displacement of the temporomandibular joint. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1997;84:241–244
34. Tanaka E, Iwabe T, Dalla-Bona DA, et al. The effect of experimental cartilage damage and impairment and restoration of synovial lubrication on friction in the temporomandibular joint. *J Orofac Pain* 2005;19:331–336
35. Nitzan DW, Kreiner B, Zeltser R. TMJ lubrication system: its effect on the joint function, dysfunction, and treatment approach. *Compend Contin Educ Dent* 2004;25:437–438
36. Cascone P, Fonzi Dagger L, Aboh IV. Hyaluronic acid's biomechanical stabilization function in the temporomandibular joint. *J Craniofac Surg* 2002;13:751–754
37. Guarda-Nardini L, Ferronato G, Favero L, et al. Predictive factors of hyaluronic acid injections short-term effectiveness for TMJ degenerative joint disease. *J Oral Rehabil* 2011;38:315–320
38. Guarda-Nardini L, Stifano M, Brombin C, et al. A one-year case series of arthrocentesis with hyaluronic acid injections for temporomandibular joint osteoarthritis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2007;103:e14–e22
39. Eriksson L, Westesson PL, Rohlin M. Temporomandibular joint sounds in patients with disc displacement. *Int J Oral Surg* 1985;14:428–436
40. Roberts CA, Tallents RH, Katzberg RW, et al. Clinical and arthrographic evaluation of temporomandibular joint sounds. *Oral Surg Oral Med Oral Pathol* 1986;62:373–376

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