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Comparisons between lysis and lavage, intra-articular steroid injections, and three-point subsynovial steroid injections using operative single-cannula arthroscopy — A retrospective analysis

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A B S T R A C T

The aim of this study is to compare the effectiveness of intra-articular and three-point sub-synovial steroid injections.

In this retrospective Cohort study an OSCA lysis and lavage, intra-articular and threepoint sub-synovial steroid injections were performed and the maximal interincisinal opening (MIO), pain using 10- point visual analog scale (VAS) and quality of life (QOL) were measured one week before the procedure and 1, 3, 6, 12 months, and 2 and 3years after surgery.

Sixty-five patients suffering from internal derangement refractory to conservative treatment charts were reviewed. successfully lowered pain (p value = 0.0012), and improved mouth opening (p value = 0.023), and quality of life (QoL) (p value = 0.003) for up to 6 months after surgery. OSCA with intra-articular CS injections effectively lowered pain (p value = 0.0025), and improved mouth opening (p value = 0.03) and QoL (p value = 0.004) for 12 months. In comparison, OSCA with sub-synovial steroid injections was significantly effective in lowering pain (p value = 0.000002), improving mouth opening (p value = 0.000004), and QoL (p value p = 0.000006) for the duration of the 36-month follow-up period within the limitations of the study it seems that the OSCA technique with site-specific, sub-synovial CS injections should be the preferred treatment approach when the priority is long-term success concerning pain relief, increased mouth opening and improved quality of life in Wilkes II-IV patients.

1. Introduction

Temporomandibular joint (TMJ) arthroscopy is a therapeutic technique for TMJ disorders involving internal derangement. The traditional arthroscopy technique, which includes the insertion of three ports — each for a single purpose, including visualization, operation, and arthrocentesis (outflow) — effectively reduces TMJ-associated pain and improves interincisal opening (McCain, 1988, 1996). Srouji et al. first introduced the operative single-cannula arthroscopy (OSCA) technique (Srouji et al., 2016), which involves only a single cannula that is used to insert a one-piece instrument containing a visualizing canal, an irrigation canal, and a working canal. This approach simplifies arthroscopy surgery, without compromising technique effectiveness (Srouji et al., 2016; Nahlieli, 2018).

TMJ arthrocentesis was initially proposed in 1991 by Nitzan et al. as a relatively simple, non-invasive, inexpensive, and highly effective procedure for the treatment of TMJ internal derangement (Nitzan et al., 1991, 1997; Alpaslan and Alpaslan, 2001). Horton first reported on intra-articular TMJ corticosteroid injection for osteoarthritis treatment in 1953 (Horton, 1953). However, the overall contribution of corticosteroid (CS) to the management of TMJ

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osteoarthritis and internal derangement remains debatable. Some studies have reported pain reduction and improvements in maximal mouth opening and joint mobility upon CS injection into the upper joint space. In contrast, others have reported that these injections can cause destructive cartilage changes (Kopp et al., 1987; Alstergren et al., 1996; Arabshahi et al., 2005; Ringold et al., 2008; Stoll et al., 2012; Stoustrup et al., 2013).

McCain was one of the first to introduce subsynovial CS injections, using the classic arthroscopic and triangulation technique. He recommended a combination of 1 mL dexamethasone 2 mg/mL and 1 mL of betamethasone 6 mg/mL (McCain, 1988, 1996). Most literature on CS injections relates to injections in the upper joint space, with only a small collection of reports referring to subsynovial CS injections.

The aim of our study was to compare the effectiveness of OSCA lysis and lavage, OSCA with intra-articular CS injections, and OSCA with subsynovial three-point, site-specific steroids injections in patients suffering from TMJ internal derangement refractory to conservative treatment.

2. Materials and methods

This retrospective cohort study was approved by the Galilee Medical Center (GMC) ethics committee (NHR 0054-16). The procedures were performed between February 2016 and February 2018 at GMC, Israel.

Each patient underwent a standard physical examination. MIO, pain, using a 10-point visual analog scale (VAS; 0 = no pain, 10 = severe pain), and quality of life (QOL) were measured 1 week before the procedure and at 1, 3, 6, 12, 24, and 36 months after surgery. QOL was recorded using a 10-point scale of patient-reported outcome measures relating to the patient's diet and chewing capability, speech, recreation activity, anxiety, mood, and sleep quality. Panoramic X-ray imaging (ProMAX 3D Classic; Planmeca, Helsinki, Finland), and magnetic resonance imaging (Tesla 1.5; General Electric, Israel) were performed during the diagnosis process prior to surgery.

To be included in the study sample, patients had to meet the following inclusion criteria: (1) over 18 years old; (2) clinical diagnosis of articular disorder of the TMJ (pain, clicking, and/or locking); (3) unilateral or bilateral TMJ involvement; (4) failed conservative treatment, including the use of a stabilization (flat-plane) appliance, physical therapy, and medications, such as non-steroidal anti-inflammatory drugs, with or without muscle relaxants, for 3–6 months; (5) MRI performed for the assessment of internal derangement of the TMJ; (6) internal derangement of the TMJ ranging from Wilkes stage II to stage IV. Patients who had undergone any prior TMJ surgery or who suffered from degenerative joint disease were excluded from the study.

All included patients received 1 g amoxicillin-clavulanic acid and 8 mg dexamethasone intraoperatively, and 875 mg amoxicillin–clavulanic acid twice a day for 7 days after the procedure. Patients began physiotherapy and active stretch on the second day after surgery.

2.1. OSCA surgical technique

While patients were under general anesthesia with nasoendotracheal intubation, arthroscopic surgery landmarks were drawn on the Holmlund-Hellsing line. First, 2 mL of bupivacaine 0.5% (SteriMax, Oakville, Ontario, Canada) was injected into the joint space. Next, a sharp trocar was introduced into the superior joint space using a standard, superior posterolateral technique. Once inside the joint, the sharp trocar was removed, and a blunt obturator was inserted to separate the soft tissues within the TMJ. The arthroscope (semi-rigid 0.9 mm-diameter endoscope, PD-DS-1083; PolyDiagnost, Hallbergmoos, Germany) was then inserted through the middle handle of the three female Luer-lock connections for irrigation and instrumentation.

The procedure was performed in one of three manners. In group 1, patients underwent one-track, OSCA lysis and lavage (level 1 OSCA). Saline was introduced and drained from the joint space through a single 2.0 mm cannula connected to the three-way handle. In group 2, patients underwent OSCA, which involved 0.5 mL intra-articular CS injections (methylprednisolone acetate 40 mg/mL; Depomedrol, Pfizer, Herzliya, Israel) through a single 2.0 mm cannula to the upper joint space (level 2 OSCA). Patients in group 3 underwent OSCA with 0.5 mL subsynovial CS injections through a single 2.0 mm cannula. The subsynovial steroid injections (methylprednisolone acetate 40 mg/mL; Depomedrol, Pfizer, Herzliya, Israel) were targeted on the pterygoid shadow of the superior head of the lateral pterygoid muscle, the retrodiscal synovium, and the anterior TMJ capsule in the anterior recess (Fig. 1).

2.2. Statistical analysis

Prism 8.0.1 software (GraphPad, USA) was used for statistical analyses. Data were expressed as mean ± standard deviation (SD). All intercohort and intracohort comparisons (postsurgery at each time-point vs presurgery) were performed using one-way or two-way analysis of variance (ANOVA). Values of $p \leq 0.05$ were considered statistically significant.

3. Results

Sixty-five patients were divided into three groups. Group 1 included 16 patients, with a mean age of 42.06 ± 14.48 years (range 21–71) and a total of 24 operated TMJs. Four patients were classified as Wilkes stage II, eight as Wilkes stage III, and four as Wilkes stage IV. Group 2 included 15 patients, with a mean age of 40.87 ± 12.14 years (range 21–62) and 21 operated TMJs. Three patients were classified as Wilkes stage II, seven as Wilkes stage III, and five as Wilkes stage IV. Group 3 included 34 patients, with a mean age of 37.91 ± 13.74 years (range 18–65), and a total of 45 operated TMJs. Seven patients were classified as Wilkes stage II, 17 as Wilkes stage III, and ten as Wilkes stage IV (Table 1). The mean patient age was similar across the cohorts.

In group 1, improvements in MIO, pain score, and QOL were recorded; however, after the initial improvement, mouth opening remained without a significant change for 6 months after surgery and began to decline from 12 months up to 36 months after surgery. Similarly, pain scores were significantly improved during the first 6 months postsurgery but started to increase from 12 months up to 36 months after surgery. QoL scores showed statistically significant improvements up to 12 months after the intervention, but started to deteriorate from 12 months up to 36 months after surgery.

In group 2, statistically significant improvements in MIO, VAS, and QOL persisted for 12 months, after which they began to decline over the ensuing 24 months.

In contrast to the other two cohorts, group 3 patients benefited from improvements that persisted throughout the entire 36-month follow-up period.

MIO, VAS, and QOL scores measured over the study period are summarized in Table 2 and Fig. 2.

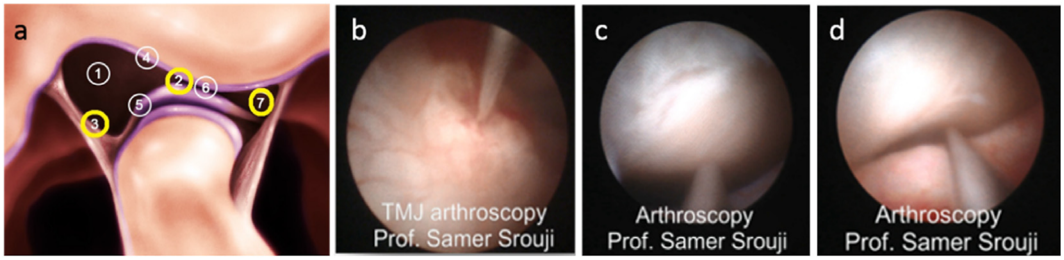

Fig. 1. (a) Illustration of a sagittal section of the TMJ with seven points of arthroscopic interest. Note the three site-specific steroid injections into the retrodiscal ligament (3), the pterygoid shadow (2), and the anterior recess (7). (b) Injection into the retrodiscal tissue. (c) Injection into the superior head of the lateral pterygoid muscle — pterygoid shadow. (d) Injection into the anterior recess.

Table 1
Patient demographics and baseline clinical characteristics.

	Group 1 (*N* = 16)	Group 2 (*N* = 15)	Group 3 (*N* = 34)
Age (mean ± SD)	42.06 ± 14.48	40.87 ± 12.14	37.91 ± 13.74
Gender	7/16	6/15	9/34
Male	9/16	9/15	25/34
Female			
Affected TMJ	3	5	10
Left	5	4	13
Right	8	6	11
Bilateral	24	21	45
Total number			
Wilkes stage	4/16	3/15	7/34
II	8/16	7/15	17/34
III	4/16	5/15	10/34
IV			
Positive joint load test	16/16	15/15	34/34

3.1. Comparing pain levels with regard to Wilkes staging

Group 1 patients had statistically significant pain relief for up to 6 months, regardless of their Wilkes staging. In group 2, Wilkes II patients reported significant pain relief for 3 months after surgery. In comparison, Wilkes III and IV patients in the same cohort benefited more from OSCA with intra-articular CS injections, reporting significant pain relief up to the 24-month follow-up. Group 3 patients, regardless of their Wilkes staging, reported a substantial improvement in pain level for the full 36-month follow-up (Table 3).

3.2. Comparing MIO with regard to Wilkes staging

Patients in groups 1 and 2 exhibited statistically significant improvements in MIO for up to 3 months after treatment, regardless of their Wilkes staging. In group 3, all patients, irrespective of

Table 2
Pre-versus postoperative VAS, MIO, and QOL values.

		Presurgery	Postsurgery (months)					
			1	3	6	12	24	36
Group 1: *OSCA lysis and lavage*	MIO	28.00 ± 6.13	33.94 ± 5.00	33.06 ± 5.16	31.31 ± 4.78	29.06 ± 5.07	26.00 ± 5.05	23.94 ± 4.96
			p = 0.0004	p = 0.002	p = 0.023	p = 0.132	p = 0.445	p = 0.865
	VAS	8.31 ± 1.40	3.31 ± 1.20	4.06 ± 0.85	4.88 ± 0.62	6.44 ± 0.73	6.63 ± 1.15	6.88 ± 1.15
			p = 0.00004	p = 0.00035	p = 0.0012	p = 0.142	p = 0.198	p = 0.216
	QOL	2.38 ± 1.36	6.56 ± 1.36	6.00 ± 1.21	5.00 ± 1.10	3.31 ± 1.14	2.94 ± 1.06	2.44 ± 0.89
			p = 0.000007	p = 0.00004	p = 0.003	p = 0.023	p = 0.3726	p = 0.9997
Group 2: *OSCA with intra-articular CS injections*	MIO	28.07 ± 6.62	35.27 ± 6.11	35.47 ± 5.76	33.67 ± 6.07	31.13 ± 5.97	29.53 ± 5.37	27.67 ± 5.21
			p = 0.00001	p = 0.0002	p = 0.004	p = 0.03	p = 0.7092	p = 0.9985
	VAS	8.27 ± 1.10	2.13 ± 1.13	2.73 ± 0.96	3.93 ± 1.28	4.60 ± 0.83	5.13 ± 0.74	5.87 ± 0.74
			p = 0.00002	p = 0.00003	p = 0.0004	p = 0.0025	p = 0.041	p = 0.097
	QOL	2.13 ± 1.19	7.00 ± 1.36	6.87 ± 1.19	6.07 ± 1.28	4.47 ± 1.51	3.53 ± 0.99	3.33 ± 0.72
			p = 0.000006	p = 0.000008	p = 0.0003	p = 0.004	p = 0.09	p = 0.119
Group 3: *OSCA with subsynovial CS injections*	MIO	27.32 ± 9.31	36.35 ± 8.15	39.26 ± 8.36	39.76 ± 7.1	40.47 ± 7.22	40.85 ± 7.05	41.82 ± 7.03
			p = 0.00003	p = 0.000021	p = 0.000011	p = 0.000008	p = 0.000006	p = 0.000004
	VAS	8.88 ± 1.27	2.91 ± 2.15	2.35 ± 1.70	1.97 ± 1.47	1.68 ± 1.3	1.68 ± 1.32	1.06 ± 1.15
			p = 0.000028	p = 0.000011	p = 0.000008	p = 0.000005	p = 0.000005	p = 0.000002
	QOL	2.18 ± 1.31	6.94 ± 1.72	7.68 ± 1.53	8.21 ± 1.3	8.41 ± 1.26	8.56 ± 1.31	8.97 ± 1.14
			p = 0.00004	p = 0.00002	p = 0.0000001	p = 0.000007	p = 0.000008	p = 0.000006

Results are presented as mean ± SD.
MIO = maximal interincisial opening, VAS = visual analogue scale, QOL = quality of life.

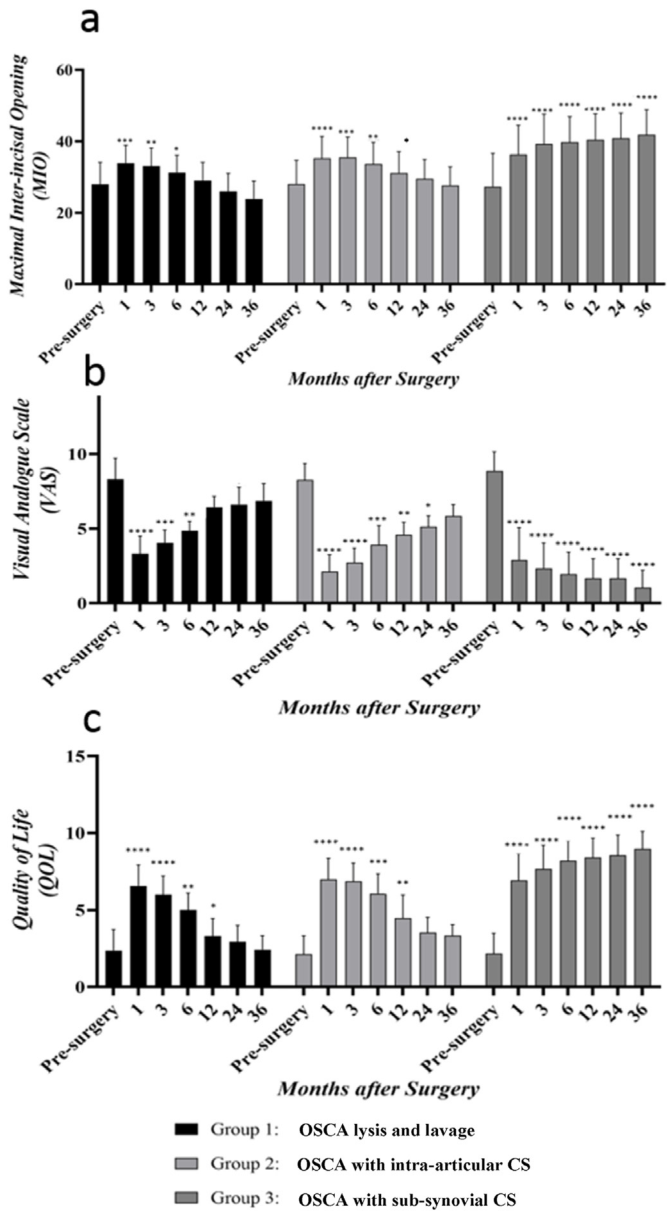

Fig. 2. MIO (mm), VAS, and QOL (pre- and postoperative).

their Wilkes staging, showed a considerable improvement in MIO level for 36 months (Table 4).

3.3. Comparing QoL with regard to Wilkes staging

QoL measurements paralleled MIO and VAS findings. In group 1, Wilkes II patients reported improved QOL for 3 months, while Wilkes III and IV patients reported improved QOL for up to 6 months after surgery. In group 2, Wilkes IV patients benefited the longest from surgery. In contrast, all patients in group 3, regardless of their Wilkes staging, reported a statistically significant improvement in QOL for 36 months (Table 5).

No postoperative complications were recorded, aside from the expected transient pain and a temporary limitation in mouth opening. Patients were discharged within 3–28 h of surgery, with a prescription for non-steroidal anti-inflammatory drugs (etodolac 400 mg, three times a day for 5 days), 875 mg amoxicillin-clavulanic acid twice a day for a postoperative period of 7 days, and instructions to use a stabilization appliance, maintain a soft diet for 7 days, and perform physical therapy. In cases where postsurgery MRI scans were available, no additional degenerative changes in bone or cartilage were noticed.

4. Discussion

Our study analyzed single-center experiences with OSCA lysis and lavage as compared with OSCA with intra-articular steroid injections or with subsynovial steroid injections in patients suffering from TMJ internal derangement. OSCA lysis and lavage was useful in lowering pain, and in improving mouth opening and quality of life for up to 6 months after surgery. In comparison, OSCA with intra-articular CS injections successfully lowered pain, and improved mouth opening and quality of life for 12–24 months postsurgery. OSCA with subsynovial three-point, site-specific steroid injections proved significantly effective in lowering pain, and in improving mouth opening and quality of life for at least 36 months. The long-term superiority of OSCA with subsynovial CS injections over OSCA lysis and lavage and OSCA with intra-articular CS injections was independent of Wilkes staging. Nevertheless, arthroscopy has several drawbacks, including the need for general anesthesia and an operating room, its relative invasiveness, the risk for postoperative morbidity, and the potential for complications (González-García et al., 2006). However, in this study, all procedures were performed with the same OSCA kit, in an operating room, under general anesthesia, and showed the same levels of morbidity, with no significant postsurgery complications.

TMJs with internal derangements refractory to conservative therapy can be treated with arthrocentesis or arthroscopy lysis and lavage. In the previous literature, there has been a general consensus that there is no significant difference in outcomes between the two approaches. Both improve MIO and pain scores, with an overall success rate of 82% for arthroscopy and 75% for arthrocentesis (Fridrich et al., 1996). In more recent publications, a meta-analysis by Al-Moraissi found a statistically significant difference in favor of arthroscopy with regard to MIO and pain (Al-Moraissi, 2015), while a network meta-analysis found (with low-quality evidence) that the most effective treatment in reducing pain intensity was arthroscopy with intra-articular platelet-rich plasma and hyaluronic acid injections. Arthroscopy with CS injections showed good results too. With regard to MIO, the most effective treatments (with low-quality evidence) were arthroscopy procedures with intra-articular platelet-rich plasma and hyaluronic acid injections (Al-Moraissi et al., 2020). Single-puncture TMJ arthrocentesis was as effective as the double-puncture technique for joint disorders (Monteiro et al., 2020). The sizes of inflow and outflow portals were found to be critical factors in determining irrigated flow rate, with a more extensive inflow portal and a smaller outflow portal leading to higher intra-articular pressure (Xu et al., 2013). In our study, OSCA lysis and lavage was performed with the same single 2 mm-diameter portal as the OSCA CS injections, and may therefore have provided the same pressure for clearance of inflammatory mediators.

Intra-articular TMJ CS injections were first introduced by Horton (1953) to treat TMJ osteoarthritis. In most studies, CS is injected into the upper joint space via blind or visually guided techniques. The contribution of CS injections into the joint space to the management of TMJ osteoarthritis remains debatable. Many investigators have reported that intra-articular injections relieve joint pain (McCrum, 2017; Liu et al., 2020) and improve maximal mouth opening, while others have raised concerns regarding the long-term side-effects on children's mandibular growth due to the close contact with an important mandibular growth site, which could lead to corticosteroid-induced craniofacial growth

Table 3
Pain measurements (VAS) in relation to Wilkes staging.

		Presurgery	Postsurgery (months)					
			1	3	6	12	24	36
Group 1: OSCA lysis and lavage	**Wilkes II**	8.25 ± 0.96	3 ± 0.82 p = 0.0008	4 ± 0.01 p = 0.0096	4.75 ± 0.5 p = 0.0384	6.25 ± 0.96 p = 0.1931	6.25 ± 1.5 p = 0.1931	6.75 ± 1.5 p = 0.2879
	Wilkes III	8.13 ± 1.46	3.25 ± 1.0 p = 0.0011	3.88 ± 0.99 p = 0.0022	4.88 ± 0.64 p = 0.0028	6.38 ± 0.52 p = 0.0520	6.25 ± 0.71 p = 0.0511	6.41 ± 0.74 p = 0.0521
	Wilkes IV	8.75 ± 1.89	3.75 ± 1.89 p = 0.0006	4.5 ± 1 p = 0.0096	5 ± 0.82 p = 0.0296	6.75 ± 0.96 p = 0.1931	7.75 ± 0.96 p = 0.7003	8 ± 0.82 p = 0.7166
Group 2: *OSCA with intra-articular CS injections*	**Wilkes II**	7.67 ± 0.58	1.33 ± 0.58 p = 0.0073	2.67 ± 0.58 p = 0.0343	3.13 ± 1.53 p = 0.01749	4.33 ± 1.15 p = 0.1612	5.33 ± 0.58 p = 0.1517	6.01 ± 0.98 p = 0.1975
	Wilkes III	7.86 ± 0.69	1.71 ± 0.7 p = 0.0007	2.43 ± 0.7 p = 0.0008	3.86 ± 1.07 p = 0.0012	4.13 ± 0.7 p = 0.004	4.97 ± 0.53 p = 0.073	5.96 ± 0.97 p = 0.141
	Wilkes IV	9.2 ± 1.3	3.2 ± 1.1 p = 0.0038	3.2 ± 1.3 p = 0.0072	4.40 ± 1.52 p = 0.0223	5.01 ± 0.71 p = 0.0285	5.80 ± 0.45 p = 0.06	5.80 ± 0.45 p = 0.06
Group 3: *OSCA with subsynovial CS injections*	**Wilkes II**	8.57 ± 1.13	1.57 ± 1.51 p = 0.0003	1.14 ± 1.68 p = 0.0005	1 ± 1.15 p = 0.0002	0.86 ± 1.07 p = 0.0002	0.86 ± 1.07 p = 0.0002	0.73 ± 0.79 p = 0.00003
	Wilkes III	8.82 ± 1.47	2.94 ± 2.11 p = 0.0002	2.53 ± 1.5 p = 0.00007	2.12 ± 1.32 p = 0.00006	1.65 ± 1.17 p = 0.00005	1.65 ± 1.17 p = 0.00005	1.06 ± 1.14 p = 0.00002
	Wilkes IV	9.2 ± 1.03	3.8 ± 2.3 p = 0.0002	2.9 ± 1.79 p = 0.00005	2.4 ± 1.71 p = 0.00004	1.64 ± 1.49 p = 0.00003	1.54 ± 1.49 p = 0.00003	1.05 ± 1.27 p = 0.00002

Results are presented as mean ± SD.

Table 4
Maximal interincisial opening measurements in relation to Wilkes staging.

		Presurgery	Postsurgery (months)					
			1	3	6	12	24	36
Group 1: OSCA lysis and lavage	**Wilkes II**	26 ± 6.16	32.5 ± 5.06 p = 0.0377	32.06 ± 4.5 p = 0.046	29.75 ± 3.77 p = 0.2286	27.25 ± 4.71 p = 0.496	25 ± 4.54 p = 0.8469	22.5 ± 3.69 p = 0.3055
	Wilkes III	28.125 ± 4.61	33.875 ± 4.32 p = 0.0024	31.182 ± 5.3 p = 0.0162	30.375 ± 4.83 p = 0.0772	28.75 ± 4.13 p = 0.0864	25.25 ± 4.92 p = 0.0928	22.875 ± 4.58 p = 0.172
	Wilkes IV	29.75 ± 9.53	37.5 ± 5.74 p = 0.02232	36.25 ± 5.37 p = 0.05422	34.75 ± 4.92 p = 0.6411	31.5 ± 7.32 p = 0.7033	28.5 ± 6.24 p = 0.9519	27.5 ± 6.13 p = 0.8119
Group 2: *OSCA with intra-articular CS injections*	**Wilkes II**	33.33 ± 1.53	40.67 ± 3.06 p = 0.00371	40 ± 4.58 p = 0.1761	38 ± 6.08 p = 0.0467	35.67 ± 5.51 p = 0.825	33.67 ± 5.03 p = 0.9998	32 ± 4.58 p = 0.9241
	Wilkes III	29.86 ± 6.96	37 ± 5.69 p = 0.0062	37.43 ± 4.5 p = 0.0131	35.71 ± 4.82 p = 0.0404	32.71 ± 4.89 p = 0.4841	30.43 ± 5.35 p = 0.9996	27.86 ± 5.7 p = 0.8813
	Wilkes IV	22.4 ± 3.58	29.6 ± 3.21 p = 0.0255	30 ± 3.94 p = 0.0402	28.2 ± 4.09 p = 0.0456	26.2 ± 4.87 p = 0.4884	25.8 ± 3.7 p = 0.4714	24.8 ± 3.35 p = 0.6148
Group 3: *OSCA with subsynovial CS injections*	**Wilkes II**	28 ± 5.07	37 ± 3.83 p = 0.00037	38.86 ± 4.14 p = 0.0004	39.25 ± 3.87 p = 0.0001	39.57 ± 3.05 p = 0.0001	39.57 ± 3.25 p = 0.0001	40.57 ± 3.15 p = 0.00008
	Wilkes III	28.06 ± 10.87	37.35 ± 10.13 p = 0.00009	40.41 ± 10.84 p = 0.00005	40.82 ± 8.96 p = 0.00005	41.59 ± 8.97 p = 0.00004	42.06 ± 8.63 p = 0.00003	43.06 ± 8.42 p = 0.00001
	Wilkes IV	25.6 ± 9.28	34.2 ± 6.65 p = 0.0009	37.6 ± 5.48 p = 0.00008	38.1 ± 5.45 p = 0.00007	39.2 ± 6.09 p = 0.00006	39.7 ± 6.18 p = 0.00006	40.6 ± 6.57 p = 0.00005

Results are presented as mean ± SD.

suppression (Stoustrup et al., 2010; Olney, 2009). Intra-articular CS injections have been also associated with increased deep infection rates of subsequent joint arthroplasty (Xing et al., 2014) and short-lived hyperglycemia in patients with diabetes mellitus (Choudhry et al., 2016; Waterbrook et al., 2017). Systematic reviews performed by Sakalys et al. and by Haigler et al. revealed that the injection of substances such as plasma rich in growth factors, platelet-rich plasma, or hyaluronic acid could reduce pain but did not significantly increase mouth opening (Haigler et al., 2018; Sakalys et al., 2020). However, a study by González et al. showed improvement in maximal intercuspal distance as well (González et al., 2021). A comparison of platelet-rich plasma, CS, and hyaluronic acid intra-articular injections found that all three induced significant improvements in clinical pain scores, with the most considerable improvement measured in the platelet-rich plasma group (Gokçe Kutuk et al., 2019).

The rationale behind performing OSCA with subsynovial site-specific CS injections was to deliver a localized dose into tissues that benefit most from the CS anti-inflammatory effect, with minimal side-effects, and to subsequently reduce patients' pain and improve range of motion. In the authors' opinion, injecting CS into the retrodiscal ligament is clinically justified, because the tissue is highly innervated and highly vascularized, and therefore susceptible to injury in TMJs with internal derangements. The pterygoid shadow is the insertion site of the superior head of the lateral pterygoid muscle, which comprises part of the TMJ capsule's medial aspect and may play a role in myofascial pain. The anterior recess is the insertion point of some additional fibers of the lateral pterygoid muscle and comprises, together with the anterior synovium, the TMJ capsule's anterior aspect. Although the bioavailability and systemic effect of CS injected into the joint space are quite similar to those of subsynovial or intramuscular injections, their pharmacokinetic and pharmacodynamic profiles are assumed to be different. In both techniques, the levels of hypothalamic-pituitary-adrenal suppression and decreased cortisol have been found to be similar and dose-dependent (Lazarevic et al., 1995). However, while the retention time of CS in the joint space is unknown, intra-articularly injected steroids are assumed to be absorbed over a 2–3 week

Table 5
Quality of life measurements in relation to Wilkes staging.

		Presurgery	Postsurgery (months)					
			1	3	6	12	24	36
Group 1: OSCA lysis and lavage	**Wilkes II**	2.75 ± 1.26	7.25 ± 0.96 p = 0.0331	6 ± 0.82 p = 0.0412	5 ± 1.15 p = 0.2757	3.75 ± 1.26 p = 0.8469	3.25 ± 1.5 p = 0.9857	3.5 ± 0.58 p = 0.8119
	Wilkes III	2.5 ± 1.6	6 ± 1.31 p = 0.0071	5.75 ± 1.39 p = 0.0082	4.88 ± 1.25 p = 0.0554	3.5 ± 0.93 p = 0.3858	3.13 ± 0.83 p = 0.5276	2.13 ± 0.64 p = 0.9452
	Wilkes IV	1.75 ± 0.96	7 ± 1.63 p = 0.0361	6.5 ± 1.29 p = 0.025	4.25 ± 0.96 p = 0.0889	2.5 ± 1.29 p = 0.5382	2.25 ± 0.96 p = 0.8119	2 ± 0.82 p = 0.9943
Group 2: *OSCA with intra-articular CS injections*	**Wilkes II**	3.33 ± 0.58	7.67 ± 0.58 p = 0.0155	7.33 ± 1.15 p = 0.0428	6.97 ± 2.08 p = 0.0482	5.02 ± 2.04 p = 0.4623	3.67 ± 1.15 p = 0.8122	3.67 ± 1.15 p = 0.8122
	Wilkes III	2.29 ± 1.25	7.29 ± 1.6 p = 0.003	7.14 ± 0.69 p = 0.0011	6 ± 1.15 p = 0.0102	4.57 ± 1.4 p = 0.0362	3.57 ± 1.13 p = 0.0833	3.14 ± 0.38 p = 0.4329
	Wilkes IV	1.2 ± 0.45	6.2 ± 1.1 p = 0.0013	6.2 ± 1.64 p = 0.0076	5.8 ± 1.1 p = 0.0056	4 ± 1.58 p = 0.0446	3.4 ± 0.89 p = 0.0548	3.4 ± 0.89 p = 0.0548
Group 3: *OSCA with subsynovial CS injections*	**Wilkes II**	2.57 ± 0.98	8.57 ± 1.13 p = 0.0003	8.57 ± 1.72 p = 0.002	8.86 ± 1.35 p = 0.0008	9.29 ± 0.76 p = 0.00004	9.29 ± 0.76 p = 0.00004	9.43 ± 0.79 p = 0.00005
	Wilkes III	1.94 ± 1.39	6.59 ± 1.87 p = 0.0004	7.35 ± 1.58 p = 0.0003	8.12 ± 1.27 p = 0.00007	8.41 ± 1.33 p = 0.00006	8.59 ± 1.5 p = 0.00005	9 ± 1.37 p = 0.00003
	Wilkes IV	2.3 ± 1.42	6.4 ± 1.07 p = 0.0005	7.6 ± 1.17 p = 0.00006	7.9 ± 1.29 p = 0.00005	7.8 ± 1.14 p = 0.00005	8 ± 1.05 p = 0.00004	8.6 ± 0.84 p = 0.00002

Results are presented as mean ± SD.

period (Derendorf et al., 1986), while the impact of intramuscular steroid injections may last for about 12 weeks, which provides for more prolonged pain reduction and mobility improvements (Dorleijn et al., 2018).

The amount of CS remaining in the joint space following intra-articular injection is difficult to predict, as some may spill out of the joint. Moreover, the remaining steroids are diluted in the joint synovial fluid. In contrast, when injecting subsynovially into a tissue, the suspension is confined to the injection site and spreads less to adjacent structures.

When performing site-specific, sub-synovial CS injections, the anti-inflammatory effect of steroids is presumably higher than that registered following intra-articular injection, due to direct contact with the inflamed tissue. Performing site-specific injection using the triangulation technique requires a high level of coordination and may be challenging for a less experienced surgeon. Using the three-way handle in a straight line extending from the arthroscope facilitates the injection, which, in our experience, is simple and easy to learn and perform, and results in a rapid and steep learning curve for a novice surgeon.

The relatively small sample size and the limited literature sources that addressed the benefits of sub-synovial CS injections represented limitations of our study. Moreover, the retrospective nature of the study precluded the inference of a true causal relationship, necessitating that more prospective studies investigating the long-term effects of sub-synovial CS injections be performed.

5. Conclusion

Within the limitations of the study it seems that the OSCA technique with site-specific, subsynovial CS injections should be preferred when long-term success concerning pain relief, increased maximal mouth opening, and improved quality of life in Wilkes II-IV patients is the priority.

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