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All-Arthroscopic Versus Mini-Open Rotator Cuff Repair: Isokinetic Muscle Strength, Shoulder Joint Position Sense and Functional Outcomes

Artroskopik ve Mini Açık Rotator Manşet Yırtığı Cerrahisinin Karşılaştırılması; İzokinetik Kas Kuvveti, Omuz Eklemi Pozisyon Hissi ve Fonksiyonel Sonuçlar

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ABSTRACT

Objectives: All-arthroscopic surgery and mini-open surgery for repairing rotator cuff tears are widely used and clinically developed. The purpose of our study is to compare the functional results, isokinetic shoulder muscle strength and shoulder position sense of patients who have undergone all-arthroscopic and mini-open surgery to repair their rotator cuff tears.

Material and Methods: The results from 28 patients (20 females and 8 males) with isolated rotator cuff tears were evaluated. Twelve had have all-arthroscopic surgery (ASR) (mean age 54.3 yrs) and 16 had have mini-open surgery (MOP) (mean age 51.5 yrs). Clinical and functional results were compared using the American Shoulder and Elbow Surgeons (ASES), and Disabilities of the Arm, Shoulder and Hand (DASH) indices. Shoulder Muscle Strength and shoulder joint position sense were measured with an isokinetic dynamometer (CSMI Humac Norm, USA).

Results: Mean age of the patients was 52.8 yrs (min-max: 40-67). Mean post-operative ASES and DASH scores of ASR-operated patients were 78 and 18.8, respectively. MOP- implemented patients had mean ASES and DASH scores of 86 and 13.6, respectively. As for functional results, there was no statistically significant difference ($p>0.05$). For patients who went through either surgery, there were no statistically significant different result in terms of isokinetic shoulder muscle strength (internal rotation, external rotation, adduction, abduction) and joint position sense results ($p>0.05$).

Conclusion: There were no significant differences between two methods in means of functional outcomes, joint strength and position sense. But, these two methods should be investigated by more comprehensive studies.

Keywords: Shoulder joint, joint position sense, rotator cuff tear, isokinetic muscle strength

ÖZ

Amaç: Rotator manşetin artroskopik ve mini açık onarımları klinik pratikte sıklıkla kullanılmakta ve geliştirilmektedir. Bu çalışmanın amacı artroskopik ve mini açık cerrahi

ile rotator manşet onarımı yapılan hastaların; fonksiyonel sonuçlarını, izokinetik omuz kas kuvvetlerini ve eklem pozisyon hissini karşılaştırmaktır.

Gereç ve yöntem: İzole rotator manşet yırtığı ile tedavi edilen ve izlenen 28 hastanın (20 kadın, 8 erkek) sonuçları değerlendirildi. Hastaların 12'si artroskopik (yaş ortalaması 54.3 yıl), 16'sı ise mini-açık teknikle (yaş ortalaması 51.5 yıl) tedavi edildi. Klinik ve fonksiyonel sonuçlar, Amerikan Omuz ve Dirsek Cerrahları (American Shoulder and Elbow Surgeons; ASES) ve Kol, Omuz ve El Özürlülükleri (Disabilities of the Arm, Shoulder and Hand; DASH) ölçekleri kullanılarak değerlendirildi. Omuz kas kuvveti ve ekleminin pozisyon hissi Cybex Norm (CSMI Humac Norm, ABD) izokinetik dinamometre ile ölçüldü.

Bulgular: Hastaların yaş ortalaması 52.8 (min-maks: 40-67) yıldı. Artroskopik tamir ile tedavi edilen hastaların ortalama postoperatif ASES skoru 78, DASH skoru 18.8 puandı. Mini-açık cerrahi tekniği ile tedavi edilen hastaların ortalama postoperatif ASES skoru 86, DASH skoru 13.6 puandı. Fonksiyonel sonuçlar açısından istatistiksel olarak anlamlı bir fark bulunmadı ($p>0.05$). Mini-açık veya artroskopik teknik uygulanan hastaların izokinetik omuz kas kuvveti (iç-dış rotasyon ve adduksiyon-abduksiyon) ve eklem pozisyon hissi ölçümlerinde istatistiksel olarak anlamlı fark belirlenmedi ($p>0.05$).

Sonuç: İki yöntem karşılaştırıldığında; fonksiyonel sonuçlar, izokinetik kuvvet ve eklem pozisyon hissi yönünden anlamlı farklılık görülmemiştir. Ancak bu iki yöntem arasındaki farkların daha kapsamlı çalışmalarla değerlendirilmesi gerektiği düşünülmektedir.

Anahtar Sözcükler: Omuz eklemi, eklem pozisyon hissi, rotator manşet yırtığı, izokinetik kas kuvveti

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INTRODUCTION

Rotator cuff tears are a common cause for shoulder pain. They affect the quality of life because of loss of strength and range of motion (1). The purpose of rotator cuff surgery is to decrease pain and increase functionality of the joint (2-6). Although recent studies show that in the long run the results of arthroscopic surgery and mini open surgery provide similar functionality gain; in the post-operative period arthroscopic surgery patients have positively superior clinical outcome. There are many studies on rotator cuff tear operations (2-5). Unfortunately, there is no common agreement about the method to be preferred. There is recently some inclination towards arthroscopic surgery, as a less invasive method (7,8).

In the literature, there are reports about shoulder strength examination after open rotator cuff repair through isokinetic testing, but omitting proprioception. In patients with full thickness tears, prior to rotator cuff repair, greatest isokinetic shoulder strength deficits were found in abduction, followed by flexion and external rotation. (6,9-13) Previous studies have utilized isokinetic, isometric or manual strength tests to examine shoulder weakness in patients with rotator cuff pathology. A manual muscle strength test is commonly used to measure and compare surgery success. This method is inaccurate and not reproducible, whereas the use of instruments for testing enables follow-up with an objective, accurate and reproducible quantification of strength recovery. Isokinetic testing has been reported to be an objective, useful, reliable and accurate means of analyzing shoulder strength after rotator cuff repair (9,10,13-15).

It is a known fact that proprioception is compromised in musculoskeletal disorders. Especially injuries of the lower extremities have been subject of interest in studies (16,17). In case of shoulder injuries, there is limited data on the instability of shoulder, idiopathic frozen shoulder, and subacromial impingement syndrome (18-21). The effect of rotator cuff tear on shoulder proprioception is still not fully known. The purpose of the study is to compare clinical trial results of mini open surgery (MOP) with those of arthroscopic surgery (ASR). Our hypothesis is based on the assumption that arthroscopic surgery patients' proprioception follow-up results

would be better than those of mini-open surgery patients.

MATERIAL AND METHODS

The study protocol was reviewed and approved by Metin Sabanci Baltalimani Bone Diseases, Education and Research Hospital investigational review board (15.03.2019 No: 131). All data of patients who went through operation after a rotator cuff tear diagnosis between January 2015 and January 2018 were screened. Twenty eight patients were included in the study. Twelve patients that went through ASR were assigned as group 1 and 16 patients that went through MOP were assigned as group 2. Average follow-up for all patients was 22 months, with a minimum of 12 months.

Study inclusion criteria were: age between 40-65, full-thickness tears in the supraspinatus with healthy subscapularis and healthy contralateral shoulder. Criteria for omitted patients from the study were: patients with partial tears or massive supraspinatus tears, glenohumeral degenerative-arthritis, neurological pathology, cervical disk hernia and contralateral shoulder disease.

Disabilities of the Arm, Shoulder and Hand (DASH), and American Shoulder and Elbow Surgeons (ASES) isokinetic strength test results (min. 0, max. 100), and joint position sense results were used for patients' functional shoulder evaluations. Isokinetic testing allows evaluation of strength levels of a shoulder after rotator cuff repair (22).

Isokinetic muscle strength and joint position sense measurements:

A computerized isokinetic dynamometer (Cybex Norm, CSMI Humac Norm, USA) was used at 60°/s and 180°/s constant angular velocity to test internal rotation (IR), external rotation (ER), abduction and adduction of the muscles. All participants had 15 min warm-up exercise prior to the protocol implementation. Tests started with the healthy arm. IR and ER muscle strength were tested, as patients were sitting with their arm on the side and elbow at 90° flexion (23,24). During the measurements, joint rotation range was restricted to allow 45° in IR and 45° in ER. Body and hip were fixed via bands. Patients got familiarized with the machine through a five repetition set as a pre-test. Following that, a similar set was conducted with maximum effort at a 60°/s angular velocity. After 1 min of rest, the second part of the test was conducted with 15 maximum effort repetitions at 180°/s angular velocity. At the same position, joint position sense (JPS) measurements were conducted. Continuous passive motion (CPM) mode of the isokinetic test machine was used at a 1°/s angular velocity. For patients' arm to get familiar with the position, arms were hold in target angle position (25°and 75°) for 10 s and then returned to the start position.

Blasier et al. (25) determined joint position sense at the median range of motion of IR and ER (45° and 75° target angles, respectively). Patients were asked to tell when they think the target angle was reached, with their eyes closed. The difference between patient's claimed position angle and actual target angle was recorded from the graph on the screen. The procedure was repeated for each target angle for three times. Means for each target angle were calculated. Same test procedure repeated for the other shoulder after 5 min rest. As patients got tired after the tests, they were called back the following week for the other tests.

Abduction and adduction (ABD/ADD) strength test protocol: While the patient sat, body was supported at 40° with the vertical (20). Test was conducted at scapular plane with ABD movement span of 0-120°. Patients got familiarized with the machine through a five repetition set as a pre-test. Following that a similar set was conducted with maximum effort at 60°/s angular velocity. After 1 min of rest, the second part of the test was conducted with 15 maximum effort repetitions at 180°/s angular velocity. At this position, proprioception was evaluated. Positions of patients during the tests are shown in Figure 1. Parameters of the isokinetic results that were used in the analysis are peak torque (PT) (in Nm units, as maximum observed value), total work (TW) (in J units, total work through repetitions).

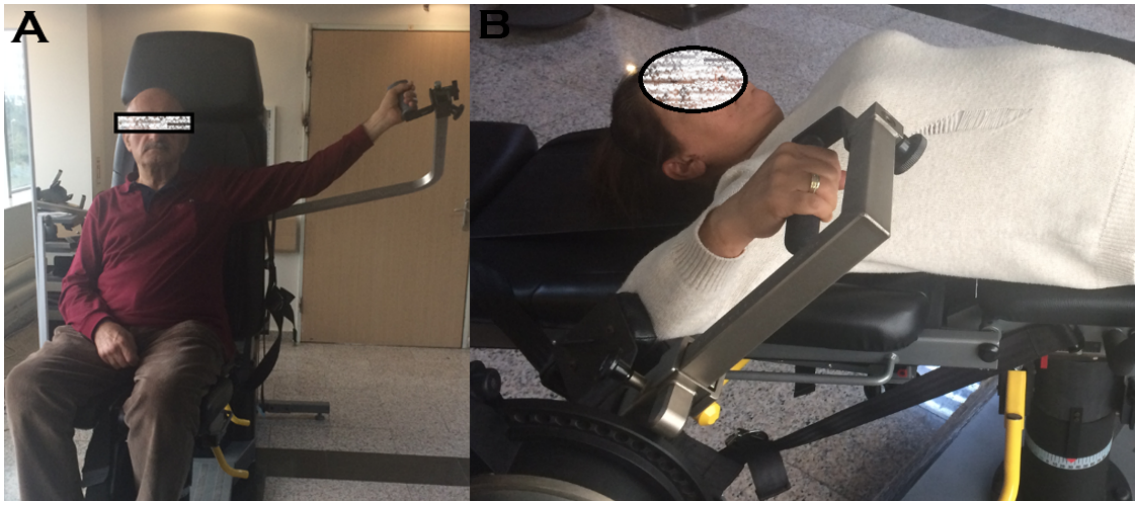

Figure 1. (a): subject performing shoulder abduction/adduction in seated position; (b): subject performing shoulder IR/ER at 90° of abduction in supine position

Surgical Technique

Arthroscopic technique: All patients were operated under general anesthesia in the lateral decubitus position with the arm held in a three-point shoulder distraction device. First of all, the arthroscope was placed in the subacromial space through a standard posterior portal; lateral and posterolateral working portals and diagnostic arthroscopy was performed on the glenohumeral area. Mid-lateral portal was preferred for subacromial space. After evaluating the glenohumeral joint and the subacromial space arthroscopically, arthroscopic myoplasty, coracoacromial ligament relaxation and subacromial bursectomy were implemented to all patients. While arthroscopic myoplasty was being performed, a 5.5 mm bar was placed in the mid-lateral portal and anterolateral space under the acromion and that area was flattened. The rotator cuff adjacent to tuberculum majus was decorticated with a burr. First the articular side, then the bursal face of the rotator cuff was debrided.

Tear size was evaluated intraoperatively in all patients. To measure the size of the tear, its location with the largest diameter was measured with the aid of a calibrated probe. The tear was mobilized from surrounding tissue. The anatomic adhesion of the tendon -opened as an accessory- from the superolateral portal was attached with a 5 mm metal suture bar (MitekFastin RC; DePuyMitek, Raynham, MA). The sutures were implemented with the help of an angled suture threaded all through 1 cm medial of the tendon edge. Single row suture technique was applied to all patients.

Mini-open surgical technique: All patients were operated under general anesthesia and in the lateral decubitus position. Longitudinally a 5 cm skin incision extending laterally from the acromion to the distal was performed. The superficial deltoid fascia was observed and was overcome by using a deltoid split incision. After acromioplasty, the rupture in the rotator cuff was mobilized from the surrounding tissue. Sutures of 5 mm were performed on the tuberculum majus to attach the anatomic adhesion of the tendon. Rotator cuff repair was performed with the single row suture technique. There were no intraoperative complications recorded for both techniques.

Rehabilitation protocols for both groups were similar. Postoperatively, the patients were maintained in an immobilizing device (30° abduction

pillow) and began passive range of motion treatment in the frontal plane and external rotation arc immediately after surgery. Active-assisted supine motion was begun at six weeks. Resistive exercises started at three months.

Statistical Analysis

For data obtained from pre-surgery and following the final examinations, descriptive statistical values were used; mean standard deviation, median, minimum, maximum, frequency and ratio. Distribution of variables was measured with the Kolmogorov Simirnov test. Mann-Whitney U test was used for the analysis of quantitative independent data. Wilcoxon test was used for the analysis of dependent quantitative data. For the analysis of independent qualitative data the chi-square test was used. When chi-square test conditions were not met, the Fischer test was used. All the statistical analyses were performed by using SPSS 22.0 software.

RESULTS

Mean age of the 28 patients was 52.7 years. Of the patients, 19 (67%) were female and nine (33%) were males. Out of 28 operated shoulders; 21 (75%) were right, 7 (25%) were left shoulders. All of the rotator cuff tears were at the supraspinatus muscle insertion's osteotendinous junction. All patients in our study had 1-3 cm (medium-sized) supraspinatus muscle tears (tears are classified as: small (<1 cm), medium (1-3 cm), large (3-5 cm) and massive (>5 cm). Average rehabilitation period was 16 months (min 6-max 29 mo). For groups; characteristics, age, gender, involved extremity, dominant extremity, rehabilitation period and BMI data were compared (Table 1). There were no statistically significant differences between the data of the two groups.

Table 1. Baseline characteristics for arthroscopic (Group 1) and mini-open (Group 2) repairs

	Group 1	Group 2
Number of operated shoulders	12	16
Age (yrs)	54.3	51.5
Body-mass index (kg/m²)	29.3	27.5
Operated side (R/L)	9/3	12/4
Dominant side injury	7	12
Follow up (mo)	22	12
Sex (female/male)	8/4	11/5

When postoperative scores were evaluated, ASES yielded 78.1 points in the ASR group and 86.4 points in the MOP group; DASH scores were 18.8 and 13.6, respectively (Table 2); with neither data revealing statistically significant difference between the groups (p=0.3, p=0.5). There were no statistically significant differences in isokinetic muscle strength measurements and joint position sensory scores (p>0.05), (Tables 3 and 4).

Table 2. Post-operative shoulder functional scale scores

		Mean	SD	SEM	p value
ASES score	Group1	78.1	24.5	7.1	0.3
	Group2	86.4	15.6	3.9	
DASH score	Group1	18.8	23.4	6.8	0.5
	Group2	13.6	15.1	3.8	

ASES: American Shoulder and Elbow Surgeons, DASH: Disabilities of the Arm, Shoulder and Hand, SEM: Standard Error Mean

Table 3. Mean isokinetic muscle strength results

	Group 1	Group 2		Group 1	Group 2	
Angular velocity	**60°/s**		**p**	**180°/s**		p
Internal rotation						
Peak torque (Nm)	16.1	13.3	0.3	15.5	13.6	0.5
Total work (J)	15.7	13.5	0.5	15.7	13.5	0.5
External rotation						
Peak torque (Nm)	15.9	13.4	0.7	16.1	13.2	0.4
Total work (J)	15.9	13.4	0.4	15.7	13.5	0.5
Abduction						
Peak torque (Nm)	15.8	13.5	0.5	15.2	13.9	0.7
Total work (J)	15.4	13.8	0.6	13.6	15.1	0.6
Adduction						
Peak torque (Nm)	14.9	14.1	0.8	14.0	14.8	0.8
Total work (J)	15.4	13.8	0.6	15.6	13.6	0.5

Table 4. Joint Position Sense measurements of the groups

Parameter	Group 1	Group 2	
	Mean	**Mean**	**p value**
25° IR	5.1	5.5	0.4
75° ER	4.9	4.8	0.3
25 °ABD	3.1	3.5	0.3
75 °ADD	3.4	3.5	0.1

IR: internal rotation, ER: external rotation, ABD: abduction, ADD: adduction

DISCUSSION

The primary finding of the study comparing arthroscopic and mini-open repair surgery techniques was the absence of a significant difference. We have found similar shoulder strength and proprioception results for patients who were operated with all-arthroscopic or mini-open surgery. The purpose of rotator cuff surgery is to eliminate pain and reintegrate its function. Although there are many surgical techniques related to RCT, there is no definite agreement about the superiority of a given technique (6-8,26-31). In conclusion, the results did not define a technique being superior, coherent with literature. How the two techniques could be used as alternative treatment options will be discussed.

According to medical literature, various surveys were used while comparing surgical techniques. In our study, the ASES and DASH surveys were used. Postoperative ASES and DASH scores were not significantly different statistically for ASR and MOP, in line with previous studies (Table 5). Only in one of the studies, MOP results were identified to be higher than the ASR results (32).

Table 5. Studies comparing approaches to rotator cuff repair

Authors	Group	No. of patients	Follow-up (mo)	ASES S	DASH S
Kim et al. (2003)	ASR	42	39	95.0 ± 7.2	
	MOP	34	39	95.0 ± 7.3	
Severud et al. (2004)	ASR	35	44.6	91.7	
	MOP	29	44.6	90.0	
Sauerbrey et al. (2005)	ASR	28	19	86.0	
	MOP	26	33	89.0	
Youm et al. (2005)	ASR	42	37.6	91.0 ± 15.4	
	MOP	42	37.6	90.0 ± 14.8	
Verma et al.(2006)	ASR	38	24	94.6 ± 08.9	
	MOP	33	24	95.1 ± 05.3	
Bishop (2006)	ASR	40	12	84.0	
	MOP	32	12	85.0	
Kang et al. (2007)	ASR	65	6	NG	18.4
	MOP	63	6	NG	18.6
Kasten et al. (2011)	ASR	17	6	81.0	
	MOP	16	6	86.9	
Zwaal et al. (2013)	ASR	47	12	NG	51.0
	MOP	48	12	NG	51.0
Barners (2017)	ASR	128	24	82.7	
	MOP	22	24	91.0	
Present study	ASR	12	22	78.1	18.8
	MOP	16	22	86.4	13.6

Abbreviations: ASR: arthroscopic repair; MOP: mini-open repair; ASES S: American Shoulder and Elbow Surgeons Index Score; NG: not given.

Severud et al. indicate that in both ASR and MOP, rotator cuff repair functionality results were reversed within the first three months after surgery (26). Patients with a follow-up period of at least 24 months regained movement within the first three months after surgery. All patients who underwent the ASR technique claimed significantly faster joint movement compared with MOP. Wolfgang (31) reported six to nine months recovery time for loss of strength after rotator cuff repair. In our patients who completed at least six months of recovery, the joints of those in whom the arthroscopic technique were applied gained movement significantly faster than the ones in the MOP group.

In the same study (31), it was determined that tear size did not affect functional results. Similarly, according to Kirschenbaum et al., there were no differences in isokinetic shoulder flexion, ABD and ER strength, when major and minor tears were compared (9). In our study, tear size was 1-3 cm in all patients. According to Bishop et al., in tears bigger than 3 cm, clinical results of MOP were better (28). The isokinetic test is considered to be a consistent method to evaluate recovery after rotator cuff surgery (32). Isokinetic measurements of the shoulder joint are done at various angles. It can be challenging for some patients to perform the test in the required position after the surgery. Furthermore, in the preoperative phase, feasibility of the test is restricted because of limited motion, and pain concerning the rotator cuff.

Regardless of the muscle group the surgery is performed on, joint position sense could be lost to a similar degree. In rotator cuff tears, impairment in proprioception of the uninjured shoulder was shown (33). There is no standard procedure of proprioception evaluation. In our study, proprioception was evaluated using an isokinetic dynamometer system. In a study comprising 21 articles were included, and 553 shoulders of a total 407 participants were assessed, the most reliable measurement method to evaluate shoulder proprioception was concluded to be a passive protocol of IR conducted at 90° muscle ABD (34). The fact that we included this method in the present study strengthens the credibility of the data. The test was conducted for IR and ER in a medium range of motion. The results of two surgery techniques results were similar at the target angles of 25° and 75°. No differences between the two surgery techniques in proprioception evaluation of ABD-ADD movements at either target angles were recorded.

Rokito et al. found correlations between clinical and isokinetic test results after rotator cuff operations. They have emphasized that isokinetic test results were important and necessary in long term therapy (10). Durall et al. mentioned that shoulder ABD-ADD test protocols need to be repeatable and must be conducted in low and safe angular velocities (60°/s, 120°/s, 180°/s) (35). In rotator cuff pathologies, same angular velocities were mostly recommended (36). Hence we have preferred 60°/s and 180°/s angular velocities in the study.

There can be differences in shoulder test results of healthy people and rotator cuff tear operated patients. Fabis et al. recorded post-operative internal and external PT scores as 16.6 Nm and 13.7 Nm in frozen shoulder patients. Also, IR and ER passive joint position sense results were recorded as 2.4 Nm and 2.3 Nm, respectively (37). Rabin et al. defined ER-PT as 22.5 Nm for rotator cuff tear operated patients in their post-op isokinetic tests (38). Bigoni et al. recorded the IR-PT as 17 Nm and ER-PT as 21 Nm, in the first year post-op examination of patients with medium tears (32). Ito et al., in their study that evaluated post-op muscle strength of 23 patients with full thickness rupture in the supraspinatus tendon, recorded (data pairs in Nm and J, respectively) IR-PT 7.4, TW 5.2; ER-PT 4.0, TW 3.6; Abd-PT 11.5, TW 5.8; ADD-PT 12.2, TW 14.3 at 60°/s. For 180°/s, results were; IR-PT 7.8, TW 7.0; ER-PT 5.4, TW: 3.9; Abd-PT 10.0; TW 8.6; Add-PT 17.1, TW 14.3. In these studies, there was no comparison between the surgery techniques (39). In our study, comparing the PT and TW results, we did not find statistically significant differences between the two surgery techniques.

CONCLUSION

Regardless of which muscle group underwent surgery, similar levels of joint position sense gain or loss occur. Strength and proprioception test results should definitely be considered to optimize surgery outcomes. Isokinetic training is an important tool of evaluation, rehabilitation and performance enhancement of the athlete with shoulder injury (40). More comprehensive studies are needed to compare the outcomes of these two popular shoulder surgery techniques.

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