BLUE

Comparison of the Clinical Outcomes of Open Surgery Versus Arthroscopic Surgery for Chronic Refractory Lateral Epicondylitis of the Elbow

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abstract

Numerous surgical options have been introduced for the treatment of chronic refractory lateral epicondylitis of the elbow, but it remains unclear which option is superior. The clinical outcomes of an open surgery group and an arthroscopic surgery group were evaluated, and the results of the 2 procedures were compared. From among patients with lateral epicondylitis refractory to 6 months of conservative treatment, 68 patients satisfying study criteria were recruited. Open surgery was performed in 34 cases (group 1), and arthroscopic surgery was performed in 34 cases (group 2). Compared with preoperatively, the 2 groups had significantly improved values for grip strength, range of motion, and Disabilities of the Arm, Shoulder and Hand score at 12 months postoperatively. Group 1 had significantly greater improvements in grip strength and visual analog scale pain score compared with group 2 (P=.048 vs P=.006). Group 2 had significantly greater (P=.045) improvement in pronation compared with group 1. Group 2 returned to work sooner than group 1. On the questionnaire regarding satisfaction with surgery 24 months postoperatively, 4 patients (12%) in group 2 reported dissatisfaction compared with no patients in group 1. Open surgery and arthroscopic surgery both yielded good clinical results. Nonetheless, for patients requiring muscle strength or having severe pain at work, open surgery would be more effective. [*Orthopedics*. 2018; 41(4):237-247.]

Lateral epicondylitis of the elbow is an overuse injury involving eccentric overload at the origin of the common extensor tendon. It may be caused by repeated microdamage to the origin of the extensor carpi radialis brevis tendon (ECRB).[1] Pathological deformity develops as a result of the excessive use of the ECRB and its failure to heal. Lateral epicondylitis of the elbow is degenerative, and unlike simply lateral epicondylitis, inflammatory cells are not detected histologically.[2] Although lateral epicondylitis of the elbow is often referred to as tennis elbow, it is more common in the general population than in athletes and has been shown to occur preferentially in individuals in their 40s.[3]

The initial treatment for lateral epicondylitis of the elbow involves rest, restriction and change in activity, and perhaps a temporary splint for immobilization, a brace, or a local injection of steroid.[4] Ninety percent of patients show improvement in response to such treatments.[5] Generally, cases without improvement after 3 to 6 months of conservative treatment require surgery. It has been reported that approximately 8% of this entire patient population is indicated for surgery.[6]

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Approximately 40 surgical options have been introduced for lateral epicondylitis of the elbow, of which the most frequently used are open ECRB release[3] and arthroscopic ECRB release.[7] Good outcomes have previously been reported for each of these options. Nevertheless, because studies directly comparing the techniques are few, it is difficult to select a surgical treatment for lateral epicondylitis of the elbow in a clinical situation.[8]

Peart et al,[9] Szabo et al,[10] and Rubenthaler et al[11] compared the open release procedure with the arthroscopic release procedure for the treatment of lateral epicondylitis of the elbow and showed that satisfactory results have been obtained using each. However, these were retrospective studies, so the analysis of preoperative factors was insufficient. In addition, according to a study by Karkhanis et al[8] that analyzed 45 studies on lateral epicondylitis of the elbow, only 4 were prospective studies involving random selection with a grade I level of evidence. Additionally, in all but 11 of the studies, clinical outcomes were reported as a single standard success rate.

In the current study, an arthroscopic surgery group and an open surgery group were compared prospectively, their clinical outcomes were compared directly, and the association of preoperative factors with clinical outcomes was analyzed. The authors hypothesized that arthroscopic surgery may have a better outcome. They sought to clarify the indications for each of these surgeries.

Materials and Methods

Study Subjects

At the authors' hospital from January 2011 to December 2015, patients were diagnosed with lateral epicondylitis of the elbow on the basis of physical examination revealing tenderness over the common extensor origin just anterior and distal to the lateral humeral epicondyle and representative positive results of the middle finger test and the Thomsen test.[12] Patients who did not show improvement in their symptoms despite conservative treatment including nonsteroidal anti-inflammatory drugs, corticosteroid injections, and exercise and elbow brace for more than 6 months were recruited for this study. The authors defined refractory cases as severe pain unmitigated by more than 6 months of conservative therapy.[13] Patients with a history of arthritis of the elbow, a history of trauma, deformity of the elbow joint, or a history of surgery in the elbow joint area as well as those treated with nonsteroidal anti-inflammatory drugs immediately prior to the study were excluded. The authors excluded patients who took nonsteroidal anti-inflammatory drugs at least once within 2 weeks of the study, as topical or oral nonsteroidal anti-inflammatory drugs may provide short-term pain relief.[14] Steroid injection may also influence the effectiveness of surgery. However, at the authors' hospital, follow-up observation occurs at least 4 to 6 weeks after steroid injection, so none of the study subjects had received a steroid injection within 4 weeks prior to surgery. In addition, steroid injection for 6 months before surgery was performed at least once and at most 5 times for each individual in the open surgery group and at least once and at most 6 times for each individual in the arthroscopic surgery group. Of the 112 patients diagnosed with lateral epicondylitis of the elbow, 76 satisfied the above criteria.

This study received approval from the Ethics Committee of Wonju College of Medicine, Yonsei University. Written consent for study participation and surgical treatment was obtained from 68 of the 76 patients. A random digit table was used to assign 34 patients to the open surgery group and 34 patients to the arthroscopic surgery group, and the surgical treatments were performed. Preoperative factors such as age, sex, affected side, disease duration, profession, preoperative sports activity, and frequency of local steroid injection were evaluated. Grip strength was measured prior to surgery and 3, 12, and 24 months after surgery and was compared between the healthy and affected sides. The visual analog scale (VAS) pain score at rest, during daily activity, and when working, range of motion of the elbow joint, and the Disabilities of the Arm, Shoulder and Hand (DASH) (basic questionnaire and work module) score were recorded prior to surgery and 3, 12, and 24 months after surgery.

In group 1 (open surgery), mean patient age was 48±8.1 years. Sixteen patients (47%) were male, and 18 patients (53%) were female. The dominant side was affected in 26 cases (76%), and the nondominant side was affected in 8 cases (24%). Mean disease duration was 25.4±6.1 months. Regarding profession, 14 patients (41%) performed heavy manual labor (according to US Department of Labor guidelines[15]), 8 patients (24%) were homemakers, 6 patients (18%) performed clerical work, 4 patients (12%) were teachers, and 2 patients (6%) were drivers. Regarding level of preoperative sports activity, 8 patients (24%) engaged in no sports activity, 18 patients (53%) engaged in recreational activities, and 8 patients (24%) played soccer, baseball, or another activity in which body contact was abundant or exercise was extreme. A mean of 3.2±1.5 steroid injections had been administered.

In group 2 (arthroscopic surgery), mean patient age was 49±7.8 years. Twelve patients (35%) were male, and 22 patients (65%) were female. The dominant side was affected in 24 cases (71%), and the nondominant side was affected in 10 cases (29%). Mean disease duration was 26.1±6.8 months. Regarding profession, 12 patients (35%) were homemakers, 10 patients (29%) performed heavy manual labor, 6 patients (18%) performed clerical work, 2 patients (6%) were teachers, 1 patient (3%) was a retired bowler, and 3 patients (9%) had no profession. Regarding level of preoperative sports activity, 12 patients (35%) engaged in no sports activity, 16 patients (47%) participated in recreational exercise, and 6 patients (18%) played soccer, baseball, or another activity in which body contact was abundant or exercise was extreme. A mean of 3.1±1.7 steroid injections had been administered.

Regarding the preoperative factors evaluated, none showed a significant difference between the 2 groups (**Table 1**).

Table 1

Comparison of Patient Characteristics[a]

Characteristic	Group 1[b]	Group 2[c]	*P*
Sex, No.			.493[d]
Male	16 (47%)	12 (35%)	
Female	18 (53%)	22 (65%)	
Age, mean±SD, y	48±8.1	49±7.8	.514[e]
Affected side, No.			.533[d]
Dominant	26 (76%)	24 (71%)	
Nondominant	8 (24%)	10 (29%)	
Duration of disease, mean±SD, mo	25.4±6.1	26.1±6.8	.622[e]
Local steroid injection, mean±SD, No.	3.2±1.5	3.1±1.7	.454[e]
Profession, No.			.745[d]
Manual laborer	14 (41%)	10 (29%)	
Homemaker	8 (24%)	12 (35%)	
Clerk	6 (18%)	6 (18%)	
Teacher	4 (12%)	2 (6%)	
Athlete	0	1 (3%)	
Driver	2 (6%)	0	
None	0	3 (9%)	
Preoperative sports activity, No.			.834[e]
None	8 (24%)	12 (35%)	
Recreational activity	18 (53%)	16 (47%)	
Contact sports	8 (24%)	6 (18%)	

[a]*Percentages may not total 100% due to rounding.*
[b]*Open surgery.*
[c]*Arthroscopic surgery.*
[d]*Chi-square test.*
[e]*Independent sample* t *test.*

Surgical Techniques

Both procedures were performed by a single surgeon (D.S.K.).

Open Surgery. Open surgery was performed according to the conventional method defined by Nirschl and Pettrone.[3] Under general anesthesia, all patients were placed in the supine position. Tourniquets were applied and compressed at 250 mm Hg. Based on the origin of the common extensor, an approximately 4-cm incision was made on the skin, the extensor carpi radialis longus and the common extensor tendon were exposed, and the fascia of both tendons was incised and then retracted. After the origin of the ECRB was exposed, the lesion was removed. If ruptured tendons were detected, then debridement was performed, and the joint capsule around the lesion was also debrided (**Figure 1**). Decortication or multiple drilling was performed on the lateral epicondyle. After removal of the lesion was ensured, the ECRB was approximated together with the common extensor tendon (**Figure 2**). After irrigation, the fascia of the extensor carpi radialis longus and the common extensor tendon was sutured. After skin suture, a long arm splint was applied.

Arthroscopic Surgery. Under general anesthesia, all patients were placed in the prone position with 90° abduction of the shoulder joint and 90° flexion of the elbow joint. A tourniquet was applied and compressed at 250 mm Hg. The surgeon marked the lateral and medial epicondyles, the olecranon, the head of the radius, and the capitellum. The traveling direction of the ulnar nerve was marked. With an 18-gauge needle and via a lateral approach, approximately 30 mL of normal saline was injected into the elbow joint to expand the joint capsule. With a No. 11 scalpel, a proximal medial portal was established at 2 cm proximal and 2 cm anterior to the medial epicondyle. After skin incision, small forceps were used to separate subcutaneous tissues, a cannula was inserted into the joint, and a 3.5-mm 30° arthroscope was inserted. A needle was inserted into the lateral portal, and an arthroscope was inserted through the proximal medial portal; after the proximal lateral portal location was confirmed, a skin incision was made. Subcutaneous tissues were separated with small forceps, and a cannula was inserted through the needle insertion site so that the lateral portal to be used as a working portal was prepared.

An arthroscope was inserted into the proximal medial portal to examine the lateral joint capsule and the undersurface of the ECRB and was then advanced along the radial head to directly assess the ECRB and the origin of the lateral epicondyle (**Figure 3**). A shaver was inserted into the lateral portal, the joint capsule located in the undersurface of the ECRB was removed, and debridement of the ECRB to the origin of the lateral epicon-

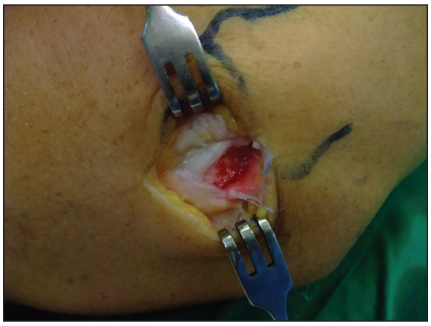

Figure 1: Intraoperative photograph showing retraction of the common extensor origin. All pathologic tissue was excised on the extensor carpi radialis brevis tendon and its origin.

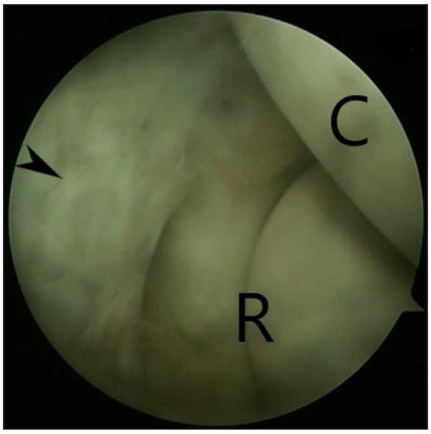

Figure 3: Arthroscopic image showing Baker type 2 lesion on the extensor carpi radialis brevis tendon (arrow). Abbreviations: C, capitellum; R, radius.

dyle was performed. Afterward, with an arthroscopic burr, decortication was performed on the lateral epicondyle and the ridge of the lateral epicondyle at the origin of the ECRB (**Figure 4**). A simple suture was used for all portals, and a long arm splint was applied.

Postoperative Rehabilitation

The 2 groups participated in the same postoperative rehabilitation regimen. From 2 to 4 days postoperatively, splinting was applied. Hand and phalanx joint exercises were performed. Patients with reduced pain postoperatively were allowed to perform active exercises of the elbow joint 1 week after surgery. Isometric exercises were started 2 weeks postoperatively. At 3 weeks postoperatively, returning to activities of daily living was recommended. At approximately 6 weeks postoperatively, returning to work and preoperative sports activity was recommended. If patients wanted to return to their level of preoperative sports activity and work because pain was reduced and symptoms were improved, they were allowed.

Figure 2: Intraoperative photograph showing the sutured common extensor origin with extensor carpi radialis brevis.

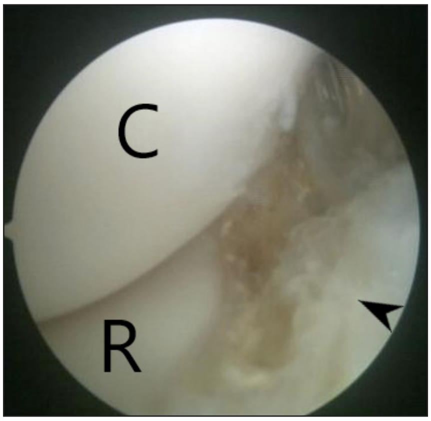

Figure 4: Arthroscopic image showing the extensor carpi radialis brevis tendon (arrow) with debridement and abraded lateral epicondyle. Abbreviations: C, capitellum; R, radius.

Postoperative Evaluation

All 68 patients had 12- and 24-month follow-up. At 3 months postoperatively, when all patients had returned to their preoperative profession and sports activity,[14] and at 12 and 24 months postoperatively, the following items were measured.

The VAS score was used to establish the level of pain experienced by the patients. Pain was measured when patients were at rest, engaged in daily activities, and at work. The VAS score could range from 0 points (no pain) to 10 points (the most severe pain imaginable).

Grip strength was measured with an electronic hand dynamometer (KS-301; Lavisen, Namyangju-si, Gyeonggi-do, Republic of Korea), and the grip strength of the affected side was compared with that of the healthy side.[16] If pain was felt during the measurement of grip strength, remeasurement occurred until there was no pain, with 2 measurements being recorded and their average calculated. The grip strength of the healthy side was also measured twice and the average calculated.

Flexion, pronation, and supination were measured to determine the range of joint movement and the maximal angle that the joint could actively move. Because for all patients the range of joint movement of the affected side was confirmed to be normal, comparison with the healthy side was not performed.

All patients were asked 4 questions from the work module of DASH. The maximum score was 100 points.

The time of return to work and preoperative sports activities was assessed at the observation performed 3 months postoperatively. The time of return to work was defined as the time the patient started work identical to that before surgery. The time of return to sports activities was defined as the time the patient started sports activities identical to those before surgery.

At 24 months postoperatively, patients were asked for their subjective opinion about the procedure. Their opinion was classified as very unsatisfactory, unsatisfactory, satisfactory, or very satisfactory.

Statistical Analysis

All statistical analyses were performed using PASW statistics version 18.0 (SPSS Inc, Chicago, Illinois). The differences in the mean preoperative and 3-, 12-, and 24-month postoperative values were analyzed by the Student's *t* test. The analysis of covariance was performed on the values from 3 months postoperatively obtained by considering preoperative values as covariates, the values from 12 months postoperatively obtained by considering the values from 3 months postoperatively as covariates, and the values from 24 months postoperatively obtained by considering the values from 12 months postoperatively as covariates. The clinical outcomes of the 2 groups 3, 12, and 24 months postoperatively were compared. With the use of repeated measures analysis of variance, the repeated values of prior to surgery, 3 months postoperatively, 12 months postoperatively, and 24 months postoperatively of the 2 groups were compared.

The chi-square test was used to analyze preoperative dichotomous and nominal variables. For the analysis of continuous variables, the 2 groups were compared using the Student's *t* test. For the analysis of the correlation of clinical outcomes to preoperative variables, a Pearson correlation analysis was used for continuous variables and the Student's *t* test was used for nominal variables. For variables showing a significant level of correlation on univariate analysis, the significance was validated by multivariate regression analysis. Clinical outcomes according to technique were also revalidated by multivariate regression analysis performed after controlling for other variables. The significance level of each analysis was defined as $P<.05$.

Results

Preoperative VAS pain score, grip strength, range of the motion of the elbow joint, and DASH score (general questionnaire and work module) were not found to be significantly different ($P>.05$) between the 2 groups. For clinical outcomes assessed 3 months postoperatively compared with preoperatively, significant improvement was observed in all categories except range of pronation of the elbow joint in group 1. In group 2, significant improvement was observed in all categories. Regarding the results obtained 12 months postoperatively compared with the results obtained 3 months postoperatively, significant improvement was shown in all values except the VAS pain score at rest and during daily activity in group 1. In group 2, significant improvement was observed in all categories except the VAS pain score during daily activity and at work. On comparison of clinical outcomes measured preoperatively with clinical outcomes measured 12 months postoperatively, all values showed significant improvement in both groups. Thus, the 2 surgeries were confirmed as techniques that could improve clinical outcomes. For the results obtained 24 months postoperatively compared with the results obtained 12 months postoperatively, improvement was shown in all values in group 1 and in group 2. On comparison of clinical outcomes measured preoperatively with clinical outcomes measured 24 months postoperatively, all values showed significant improvement in both groups. Thus, the 2 surgeries were confirmed as techniques that could improve clinical outcomes (**Tables 2-3**).

The improvement in clinical outcomes at 3 months postoperatively compared with preoperatively, at 12 months postoperatively compared with 3 months postoperatively, and at 24 months postoperatively compared with 12 months postoperatively was not significantly different between the 2 groups in all categories (**Table 4**). On repeated measures analysis of variance, the values measured preoperatively, 3 months postoperatively, 12 months postoperatively, and 24 months postoperatively were not significantly different between the 2 groups (**Table 4**).

On univariate analysis of the correlation of preoperative factors to the improvement in clinical outcomes, age and the work module of the DASH score were found to have a significant negative correlation. Disease duration and the level of improvement in the work module of the DASH score had a significant positive correlation. The correlation of profession and clinical outcomes was analyzed by dividing the patients into groups of either heavy manual labor or other. Among the heavy manual labor patients, the general DASH score significantly correlated negatively to the VAS score. The higher the preoperative sports activity, the significantly higher the improvement in the range in pronation movement of the joint. Surgical techniques did not correlate to the level of the improvement in clinical outcomes in all categories (**Table 5**).

For variables shown to be significant on univariate analysis, the significance was revalidated by multivariate analysis after controlling for the effect of other variables. Age negatively correlated to the improvement in the work module of the DASH score, and disease duration had a significant positive correlation with the improvement in the work module of the DASH score. On the multivariate regression analysis of surgical techniques and the level of improvement in all categories of clinical results from the preoperative evaluation to 24 months postoperatively, the improvements in grip strength and VAS score at work were significantly greater in group 1 than in group 2, and the level of improvement in the range in pronation of the elbow joint was significantly greater in group 2 than in group 1 (**Table 6**).

The median time of return to work for group 1 was after 5 weeks (range, 3-7 weeks). The median time of return to work for group 2 was after 3 weeks (range, 1-6 weeks) ($P<.001$). The median time returning to preoperative sports activities for group 1 was after 7 weeks (range, 3-10 weeks); for group 2, it was after 5 weeks (range, 3-7 weeks) ($P=.031$).

Patients' level of satisfaction was assessed 24 months postoperatively. For group 1, 6 patients (18%) were very satisfied and 28 patients (82%) were satisfied. For group 2, 8 patients (24%) were very satisfied, 22 patients (65%) were satisfied, and 4 patients (12%) were unsatis-

Table 2

Clinical Outcomes of the Open Surgery Group—Group 1

Parameter	Mean±SD								
	Preoperative	3 Months Postoperative	12 Months Postoperative	24 Months Postoperative	P^a	P^b	P^c	P^d	P^e
Grip strength[f]	79.4%±3.5%	88.4%±4.7%	94.4%±4.1%	94.9%±3.5%	<.001	.002	<.001	<.001	<.001
Range of motion									
Flexion–extension	135.0°±6.3°	140.7°±5.8°	143.1°±3.2°	142.7°±2.1°	.018	<.001	<.001	<.001	<.001
Supination	78.4°±1.9°	81.7°±3.4°	84.3°±3.8°	84.7°±4.3°	.005	.048	<.001	<.001	<.001
Pronation	79.1°±2.7°	82.6°±2.7°	84.5°±1.7°	84.9°±0.8°	.431	<.001	<.001	<.001	<.001
DASH score (general)	70.7±15.1	49.4±19.3	29.3±18.4	29.1±18.9	.043	<.001	<.001	<.001	<.001
DASH score (work module)	69.5±14.4	50.2±18.2	23.7±16.7	22.8±15.9	<.001	.008	<.001	<.001	<.001
Visual analog scale pain score									
Rest	5.8±0.9	0.8±0.7	0.8±0.7	0.3±0.9	<.001	.853	<.001	<.001	<.001
Daily activity	6.1±1.4	1.6±0.9	1.1±0.9	0.9±0.7	<.001	.165	<.001	<.001	<.001
Work	8.1±2.2	2.5±1.5	1.1±0.7	0.9±0.3	<.001	.001	<.001	<.001	<.001

Abbreviation: DASH, Disabilities of the Arm, Shoulder and Hand.
[a]Paired sample t test with values of preoperative and 3 months postoperative.
[b]Paired sample t test with values of 3 months and 12 months postoperative.
[c]Paired sample t test with values of preoperative and 12 months postoperative.
[d]Paired sample t test with values of 12 months and 24 months postoperative.
[e]Paired sample t test with values of preoperative and 24 months postoperative.
[f]Compared with normal side.

fied. Three of 4 patients who responded as unsatisfied had occupational injuries; the possibility that they were instead unsatisfied with workers' compensation could not be ruled out. A significant difference between the 2 groups was not detected (P=.91). However, the VAS score measured 12 months postoperatively was worse than the VAS score measured 3 months postoperatively for the 4 patients who responded as unsatisfied. All 4 of these patients had jobs requiring repeated exercise and greater muscle strength than the jobs of the other patients. One of them played baseball and 1 of them played basketball as preoperative sports activities.

Among the entire 34 patients of group 2, 12 patients (35%) had synovitis in the elbow joint and thus debridement was performed. In 2 cases, osteoarthritis was observed in the capitulum of the humerus. In 1 case, intra-articular loose bodies were observed and removed. According to the classification of Baker et al,[17] 14 patients had stage 1 lesions, 14 patients had stage 2 lesions, and 6 patients had stage 3 lesions. This classification of lesions was not significantly associated with clinical outcomes (P>.05).

Similarly, in group 1, intra-articular loose bodies were detected by preoperative plain radiography performed on the elbow joint in 1 case. After resection of the articular sac, the loose bodies were removed.

In group 1, 1 patient had a superficial infection of the surgical wound. Because of this infection, a delayed suture was performed.

None of the patients developed posterolateral instability of the elbow joint. In group 2, none of the patients developed complications.

Discussion

In 1999, Kraushaar and Nirschl[18] reported that the major pathophysiology of lateral epicondylitis of the elbow joint is the incomplete regeneration process due to micro-injury of the attachment area of the ECRB and the degenerative change of the origin of tendons. Since then, all treatments for lateral epicondylitis of the elbow joint have focused on removal of the lesions and the acceleration of healing.

The conventional open surgery method introduced by Nirschl and Pettrone[3] in 1979 has been used most widely. This surgery removes the lesion in the ECRB and facilitates the recovery of the local blood flow of the lateral epicondyle by the resection and drilling of the cortical bone of the lateral epicondyle. Isikan et al[19] reported that by performing open surgery according to the method of Nirschl and Pettrone, a 91% success rate was obtained. Other studies have also reported success rates of 85% to 100% .[2,20]

In the current study, similarly good clinical outcomes were obtained using the method of Nirschl and Pettrone, and continuous improvement in clinical results was observed during follow-up at 3, 12, and 24 months postoperatively. Regarding satisfaction with surgery, all patients similarly had a higher than satisfactory rating.

Despite such good outcomes, some shortcomings of the open surgery technique have been reported. Morrey[21] reported that lateral instability may develop as a result of the weakening of the lateral ligament complex after surgery. In addition, there is the possibility that a neuroma caused by the open wound may form.[22] It has also been reported that if an assessment of intra-articular lesions is necessary, even in the absence of a rupture of the ECRB, the ECRB will need to be resected.[22] In the current study, the lateral instability of the elbow joint and the formation of neuroma were not observed. Nonetheless, for the removal of intra-articular loose bodies detected by plain radiography, additional resection of the ECRB was performed in 1 case.

Since Owens et al[7] introduced arthroscopic surgery for lateral epicondylitis of the elbow in 1995, diverse results, although mostly good, have been

Table 3

Clinical Outcomes of the Arthroscopic Surgery Group—Group 2

	Mean±SD								
Parameter	**Preoperative**	**3 Months Postoperative**	**12 Months Postoperative**	**24 Months Postoperative**	***P*[a]**	***P*[b]**	***P*[c]**	***P*[d]**	***P*[e]**
Grip strength[f]	77.3%±3.3%	87.0%±4.4%	91.0%±3.7%	92.5%±2.4%	<.001	.002	<.001	<.001	<.001
Range of motion									
Flexion–extension	140.0°±6.2°	144.0°±2.2°	143.1°±3.2°	143.5°±1.8°	.018	<.001	<.001	<.001	<.001
Supination	82.4°±3.4°	84.9°±2.1°	84.3°±3.8°	85.7°±2.9°	.005	.048	<.001	<.001	<.001
Pronation	82.5°±2.8°	85.2°±2.1°	84.5°±1.7°	85.2°±2.3°	.431	<.001	<.001	<.001	<.001
DASH score (general)	69.2±16.4	49.3±20.3	32.6±19.0	30.3±20.1	.043	<.001	<.001	<.001	<.001
DASH score (work module)	68.5±14.7	46.2±18.1	40.4±16.2	29.4±15.5	<.001	.008	<.001	<.001	<.001
Visual analog scale pain score									
Rest	1.2±0.9	0.7±0.5	0.8±0.7	0.5±0.3	<.001	.853	<.001	<.001	<.001
Daily activity	1.4±1.2	1.1±0.9	1.1±0.9	1.0±0.3	<.001	.165	<.001	<.001	<.001
Work	1.8±1.4	1.7±2.2	1.1±0.7	1.0±0.8	<.001	.001	<.001	<.001	<.001

Abbreviation: DASH, Disabilities of the Arm, Shoulder and Hand.
[a]Paired sample t test with values of preoperative and 3 months postoperative.
[b]Paired sample t test with values of 3 months and 12 months postoperative.
[c]Paired sample t test with values of preoperative and 12 months and 24 months postoperative.
[d]Paired sample t test with values of 12 months and 24 months postoperative.
[e]Paired sample t test with values of preoperative and 24 months postoperative.
[f]Compared with normal side.

Table 4

Comparison of Improvement in Outcomes Between the 2 Groups at 3 and 24 Months Postoperative

Parameter	*P* 3 Months Postoperative[a]	*P* 24 Months Postoperative[b]	*P*[c]
Grip strength[d]	.124	.563	.059
Range of motion			
Flexion–extension	.701	.403	.841
Supination	.443	.304	.153
Pronation	.326	.377	.866
DASH score (general)	.135	.393	.664
DASH score (work module)	.601	.293	.283
Visual analog scale pain score			
Rest	.091	.399	.322
Daily activity	.643	.919	.881
Work	.144	.058	.238

Abbreviation: DASH, Disabilities of the Arm, Shoulder and Hand.
[a]Analysis of covariance (considering preoperative values as covariates).
[b]Analysis of covariance (values 3 months after surgery as covariates).
[c]Repeated measures analysis of variance.
[d]Compared with the normal side.

reported.[23,24] Savoie et al[24] reported that one of the advantages of arthroscopic surgery is that intra-articular lesions can be removed together with lesions in the ECRB. Further, compared with open surgery, arthroscopic surgery has esthetic advantages, avoids the complications that may develop from open surgery, and has a shorter period to return to activities of daily living, work, and sports.

The authors also observed such advantages in the current study. In the arthroscopic surgery group, intra-articular lesions such as synovitis of the elbow joint were detected in 12 patients and a loose body in the elbow joint was detected in 1 patient, which was treated during surgery. None of these patients developed complications. The time to return to work was significantly shorter in the arthroscopic surgery group compared with the open surgery group ($P<.05$). The time to return to preoperative sports activity was also significantly shorter in the arthroscopic surgery group compared with the open surgery group ($P<.05$).

This study confirmed that good results could be obtained in each of the groups undergoing the procedures. Szabo et al[10] reported that when open surgery, percutaneous surgery, and arthroscopic surgery for lateral epicondylitis of the elbow were compared, all were effective and significant differences were not observed. In addition, Peart et al[9] reported that the clinical results of open surgery and arthroscopic surgery were not significantly different. Similarly, in the current study, the improvement in clinical outcomes was not significantly different between the 2 groups (**Table 4**).

When an analysis of the correlation of preoperative factors to clinical results was performed, the authors observed that as age increased, improvement on the work module of the DASH score decreased (**Table 5**). It could be that in these older patients, the degenerative changes in the ECRB were more severe and thus their recovery of function was delayed. Nonetheless, it was observed that in cases with a long disease duration, the improvement in the DASH score was greater; thus, it appears that long-term follow-up is necessary.

On the multivariate regression analysis of the improvement in the clinical results of the 2 groups controlling for various preoperative factors, it was observed that the improvement in grip strength was significantly greater in the open surgery group compared with the arthroscopic surgery group (**Table 6**). Although arthroscopic surgery can protect muscles by avoiding injury to the fascia of the common extensor and its origin,[25] the ECRB cannot be sutured after debridement. Hence, muscle strength may be lessened in comparison with open surgery, in which the ECRB can be sutured. It appears that the quick return of the arthroscopic surgery group to daily activity and work may not allow the time required for the normal healing of the ECRB; thus, this group shows less improvement in grip strength than the open surgery group. To overcome that weakness of arthroscopic surgery, arthroscopic suture techniques for the ECRB have recently been introduced. In a study of arthroscopic surgeries, Savoie et al[24] introduced a method to suture the ECRB remaining after the release together with the extensor carpi radialis longus by the application of simple needle-retriever techniques or anchors through portals. However, such an arthroscopic suture has the disadvantage of being performed only by surgeons skilled in elbow joint arthroscopy. In addition, such an arthroscopic suture needs to be investigated further to determine whether it will be as effective as that performed during open surgery.

The improvement in the VAS pain score at work was much greater in the open surgery group than in the arthroscopic surgery group, but this difference was not statistically significant. The VAS pain score at work 24 months postoperatively was an average of 0.9 for the open surgery group vs 1.0 for the arthroscopic surgery group, which was significantly different. In particular, in 4 patients of the arthroscopic surgery group, the VAS pain score at follow-up 12 months postoperatively was poorer than that at 3 months postoperatively. These 4 patients had jobs requiring heavy manual labor, and 2 of them participated in sports activities with abundant body contact. These patients recovered quickly after arthroscopic surgery, and each returned to work after 3 to 4 weeks without great discomfort. However, they did report pain at work and insufficient muscle force. This was reflected in their satisfaction level at 24 months postoperatively, when they reported unsatisfactory surgical results because of pain during work and the weakening of muscle strength.

Regarding recovery of range of motion, the range in pronation of the joint showed greater improvement in the arthroscopic surgery group, which may be due to the quicker recovery afforded by this surgery. The range of pronation at 24 months postoperatively was an average of 84.9° in the open surgery group vs 85.2° in the arthroscopic surgery group. Significant differences between the 2 groups were not found.

On the basis of the current study's findings, among patients requiring

Table 5

Univariate Analysis of Outcomes According to Variables Considered—Improvement at 24 Months Postoperative

	Sex[a]		Age[b]		Affected Side[a]		Duration of Disease[b]		Local Steroid Injection[b]		Profession[a,c]		Preoperative Sports Activity[b]		Surgical Technique[a]	
Parameter	**Mean Change**	***P***	**Linear Correlation**	***P***	**Mean Change**	***P***	**Linear Correlation**	***P***	**Linear Correlation**	***P***	**Mean Change**	***P***	**Linear Correlation**	***P***	**Mean Change**	***P***
Grip strength	-1.17	.823	0.019	.283	-0.26	.933	0.214	.225	-0.125	.481	-2.32	.417	-0.082	.646	-4.48	.095
Range of motion																
Flexion–extension	-2.74	.267	0.053	.764	-0.34	.902	-0.113	.526	0.171	.333	-3.17	.211	-0.160	.366	1.58	.516
Supination	-0.52	.601	-0.061	.733	0.74	.507	-0.020	.912	-0.075	.673	0.43	.673	0.175[d]	.041	0.98	1.00
Pronation	-0.28	.823	0.174	.325	-0.38	.787	-0.291	.095	-0.009	.960	-0.59	.654	0.175	.324	2.05	.095
DASH score (general)	-1.99	.553	-0.202	.252	3.53	.344	0.031	.860	0.145	.412	-7.52	.024	-0.232	.187	-3.25	.323
DASH score (work module)	1.73	.511	-0.400[d]	.019	4.67	.106	0.360[d]	.036	0.267	.127	-4.06	.130	-0.168	.343	1.95	.452
Visual analog scale pain score																
Rest	-0.01	.988	0.113	.526	0.65	.226	0.311	.073	-0.111	.531	-1.12[d]	.020	-0.043	.809	-0.41	.390
Daily activity	-0.19	.723	0.109	.538	-0.34	.572	0.196	.266	-0.209	.235	-0.98	.072	-0.272	.120	-0.05	.913
Work	1.17	.074	-0.132	.457	0.24	.746	-0.057	.750	-0.001	.993	-0.23	.736	0.208	.238	-1.47	.121

Abbreviation: DASH, Disabilities of the Arm, Shoulder and Hand.
[a]*Independent sample* t *test.*
[b]*Pearson correlation analysis.*
[c]*Profession was analyzed by dividing "manual labor and athletes" and "others."*
[d]*Statistically significant.*

Table 6

Multivariate Analysis by Linear Regression of Variables Significantly Associated With Outcomes—Improvement at 12 Months Postoperative

	Age		Duration of Disease		Profession		Preoperative Sports Activity		Surgical Technique	
Parameter	***r***	***P***	***r***	***P***	***r***	***P***	***r***	***P***	***r***	***P***
Grip strength									-0.291	.048[a]
Range of motion										
Flexion–extension									-0.115	.285
Supination							0.374	.137	<0.001	.802
Pronation									0.291	.045[a]
DASH score (general)					0.161	.837			0.175	.421
DASH score (work module)	-0.400	.004[a]	0.360	.013[a]					-0.133	.443
Visual analog scale pain score										
Rest									0.152	.480
Daily activity									-0.020	.611
Work									-0.394	.006[a]

Abbreviation: DASH, Disabilities of the Arm, Shoulder and Hand.
[a]Statistically significant.

surgery for chronic refractory lateral epicondylitis and for whom the recovery of muscle strength is important or who experience severe pain while working, sufficient recovery of muscle strength may be obtained by suturing the extensor carpi radialis brevis. Therefore, open surgery may be a good choice.

This study had several limitations. The sample was small. Although the authors chose the number according to a standard effect size of 2.03 that was determined in a study by Janssen and De Smet[26] examining the responsiveness of the DASH score for surgical treatments for lateral epicondylitis of the elbow joint, the absolute number of patients was low. Additionally, the follow-up period was brief. Thus, all differences in the clinical results of the 2 procedures may not have been detected. Additionally, histological examination was not performed simultaneously, so confounding variables for clinical results according to the progression of lesions were not controlled.

Conclusion

Both arthroscopic surgery and open surgery had good clinical results for the treatment of chronic refractory lateral epicondylitis of the elbow joint. Nonetheless, for patients in whom the recovery of muscle strength is important or who experience severe pain while working prior to surgery, it is important to sufficiently explain the advantages and disadvantages of the 2 procedures and to point out that open surgery may lead to improved clinical outcomes.

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