Is Posterior Synovial Plica Excision Necessary for Refractory Lateral Epicondylitis of the Elbow?

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Abstract

Background Arthroscopic treatments for lateral epicondylitis including débridement of the extensor carpi radialis brevis (ECRB) origin (Baker technique) or resection of the radiocapitellar synovial plica reportedly improve symptoms. However the etiology of the disease and the role of the plica remain unclear.

Questions/purposes We asked if posterior radiocapitellar synovial plica excision made any additional improvement in pain or function after arthroscopic ECRB release.

Methods We retrospectively reviewed 38 patients who had arthroscopic treatment for refractory lateral epicondylitis between November 2003 and October 2009. Twenty patients (Group A) underwent the Baker technique and 18 patients (Group B) underwent a combination of the Baker technique and posterior synovial plica excision. The minimum followup was 36 months (mean, 46 months; range, 36–72 months) for Group A and 25 months (mean, 30 months; range, 25–36 months)

for Group B. Postoperatively we obtained VAS pain and DASH scores for each group.

Results Two years postoperatively, we found no differences in the VAS pain score or DASH: the mean VAS pain scores were 0.3 points in Group A and 0.4 points in Group B, and the DASH scores were 5.1 points and 6.1 points respectively.

Conclusions The addition of débridement of the posterior synovial fold did not appear to enhance either pain relief or function compared with the classic Baker technique without decortication.

Level of Evidence Level III, therapeutic study. See the guidelines for authors for a complete description of levels of evidence.

Introduction

Although the etiology of lateral epicondylitis seems to be repetitive stress or overuse [24], the pathologic features remain unclear. Originally, an inflammatory process was thought to be the cause of lateral epicondylitis [10]. Various authors have attributed the cause to other conditions including bursitis [21], synovitis [20], and degenerative arthritis [28]. In addition, the extensor carpi radialis brevis (ECRB) origin is the commonly noted source of disease [10, 29]. Other structures such as the annular ligament and lateral capsule also might be causative factors of lateral epicondylitis.

In 2005, Mullett et al. [23] reported finding a degenerative capsulossynovial fold of the leading edge of the annular ligament, and presuming it could relate to impingement, described a novel arthroscopic procedure to resect the fold leaving the common extensor origin undisturbed; they reported 93% complete relief of symptoms in 30 patients by 2 weeks after surgery. Tsuji et al. [30]

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Each author certifies that his or her institution either has waived or does not require approval for the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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subsequently reported that lateral epicondylitis with degenerative lesions in the area of the common extensor origin may involve the synovial fold and suggested that the pathologic features of the extensor origin and impingement of the synovial fold could cause the symptoms of lateral epicondylitis.

Open surgery [8, 9] and percutaneous tenotomy [26] have been advocated to treat refractory lateral epicondylitis. Baker et al. [1, 2] reported patients treated by arthroscopic débridement had 77% “much better”, and 20% “better” elbow function than their preoperative status and 87% patient satisfaction. Regardless of surgical treatment option, the reported failure rates range from 5% to 17% [2–6, 8, 11, 20, 25, 26]. New treatment modalities for refractory lateral epicondylitis such as platelet-rich plasma [12], Botox[®] (Allergan Inc, Irvine, CA, USA) [15], or extracorporeal shock wave therapy [17] reportedly are associated with 61% improvement at 6 weeks, 65% good to excellent results at 1 year, and 73% good to excellent results at 6 months after treatment, respectively; however, none of these treatments have shown superiority over surgical débridement. Furthermore, the pathologic features of epicondylitis and etiology of the condition are not completely understood [10, 18, 29].

We therefore: (1) determined whether posterior radiocapitellar synovial plica excision made an additional improvement in pain or function after the Baker technique without decortications for lateral epicondylitis; (2) determined the chronologic changes of VAS pain score after surgery; and (3) determined complications related to the two arthroscopic approaches.

Patients and Methods

We retrospectively reviewed all 57 patients who underwent arthroscopic treatment for refractory lateral epicondylitis by the senior author (IHR) from November 2003 to October 2009. The patients were diagnosed with lateral epicondylitis by physical examination using the following criteria: (1) tenderness at the lateral epicondyle over the extensor origin and (2) pain during resisted dorsiflexion of the wrist with the elbow in full extension. All patients initially had nonoperative treatment, including antiinflammatory medication, rest, activity modification, physical therapy, counterforce bracing, and corticosteroid injections. The operative indications were refractory symptoms for at least 6 months or aggravation of symptoms despite nonoperative treatment for 3 months. The contraindications were: (1) elbow instability, (2) infection around the joint, and (3) concomitant medial epicondylitis. We excluded 18 patients from this study: five for insufficient followup, four

with previous surgery on the affected elbow, three with degenerative elbow arthritis, three with cervical radiculopathy, and three receiving workers' compensation. This left 39 patients for the study: 20 patients treated with arthroscopic débridement of the ECRB origin (Baker technique without decortication) (Group A) and 18 treated with the Baker technique plus resection of the posterior radiocapitellar synovial plica (Group B). The average ages of the patients were 47 years (range, 37–63 years) in Group A and 46 years (range, 30–60 years) in Group B. There were four men and 16 women in Group A and six men and 12 women in Group B. Ten patients in Group A and six in Group B performed heavy manual labor, and 10 in Group A and 12 in Group B did office-type work. The minimum followup was 36 months (average, 46 months; range, 36–72 months) in Group A and 25 months (average, 30 months; range, 25–36 months) in Group B.

Preoperative demographics of the patients were similar between the groups except for followup period (Table 1). Preoperatively, we assessed the VAS pain score during activities of daily living [27], VAS palpation pain score at the lateral epicondyle [13], elbow function with the DASH score [7], and grip strength [22]. The preoperative VAS pain scores during activities of daily living, rating the pain from 0 (pain-free) to 10 (the most painful), were 9.0 (range, 7–10) in Group A and 9.1 (range, 8–10) in Group B. The preoperative VAS palpation pain scores were 9.0 (range, 7–10) in Group A and 9.4 (range, 8–10) in Group B. The preoperative DASH scores were 54.6 (range, 39.1–79.2) in Group A and 55.8 (range, 36.6–78.3) in Group B. The DASH questionnaire is a patient-reported outcome measure that has been validated for use after elbow surgery [7, 14].

Table 1. Demographics of the patients

Demographic factor	Group A	Group B	p value
Number of patients	20	18	
Age (years)	47 (37–63)	46 (30–60)	0.80*
Gender (male:female)	4:16	6:12	0.58 [†]
Job (heavy manual labor: office-type work)	10:10	7:11	0.53 [†]
Followup (months)	46 (36–72)	30 (25–36)	< 0.01*
Duration of symptoms (months)	14 (3–60)	11 (3–24)	0.90*
Number of steroid injections	1.0 (0–10)	0.7 (0–3)	0.62*
Trauma history at lateral epicondyle	4	2	0.13 [†]
ROM of elbow	2°–135°	3°–131°	0.75*
Tenderness at posterior radiocapitellar joint	12	9	0.54 [†]

* Wilcoxon signed-rank test, [†]Fisher's exact test.

Table 2. Clinical status of the patients

Variable	Group A	Group B	p Value
VAS pain score (0–10)			
Preoperative	9.0 (7–10)	9.1 (8–10)	0.89
2 years postoperative	0.3 (0–3)	0.4 (0–3)	0.56
VAS palpation pain score (0–10)			
Preoperative	9.0 (7–10)	9.4 (8–10)	0.19
2 years postoperative	0.9 (0–3)	0.4 (0–5)	0.07
DASH score (0–100)			
Preoperative	54.6 (39.1–79.2)	55.8 (36.6–78.3)	0.46
2 years postoperative	5.1 (0–25.8)	6.1 (0–25.8)	0.61
Grip strength (kg)			
Preoperative	39.3 (10–61)	41.8 (19–91)	0.08
2 years postoperative	57.1 (29–85)	73.4 (32–134)	0.06

The preoperative grip strength was 39.3 kg (range, 10–61) in Group A and 41.8 kg (range, 19–91 kg) in Group B. Grip strength was measured twice with a Grip Dynamometer (Zimmer, Chicago, IL, USA). Preoperative clinical status of the patients was similar between the groups (Table 2).

All surgery was performed by one surgeon (IHR). The patients were in either a supine or lateral decubitus position with either a brachial block or general anesthesia. The affected arm was immobilized at 90°-elbow flexion crossed over the chest with a Spider (Tenet, Calgary, Canada). A 4.0-mm arthroscope then was introduced toward the radial head through the proximal anteromedial portal after inflation of the elbow by injection of 30 mL normal saline. We inspected the pathologic changes of the anterior ulnohumeral and radiocapitellar joints. The small full-radius débrider then was introduced through the proximal anterolateral portal. After partial resection of the joint capsule, the ECRB was released completely from its origin at the lateral epicondyle (Fig. 1). To remove the posterior synovial fold, a viewing portal was established 1 cm proximal to the midportion of the olecranon and lateral epicondyle, and a working portal was made through the soft portal. In Group B, the posterior synovial plica around the radiocapitellar joint was resected completely, taking care not to violate the annular ligament (Fig. 2). A 100-mL Hemovac drain was inserted in the elbow through the proximal anterolateral portal, and a compressive dressing was applied with a long arm splint.

The patients wore the long arm splint for 2 to 3 days, after which the splint was discarded and the patient was encouraged to move the elbow as tolerated without any physiotherapy. Active resistive exercise was permitted after 12 weeks postoperative.

Patients were seen for followups at 2 and 6 weeks, at 3, 6, and 12 months, and then annually. All patients visited

Fig. 1A–B (A) An arthroscopic image shows the morphologic features of the capsular ligament in the elbow. The ECRB tendon lies between the capsule and the overlying extensor digitorum communis. The dashed line indicates the underlying ECRB tendon. (B) The ECRB was released completely from the origin site of the lateral epicondyle. C = capitellum; R = radial head.

the clinic. At each visit, the VAS pain score during activities of daily living was obtained. At the last followup, postoperative evaluation was performed with a clinical examination in the same manner as the preoperative evaluation, including ROM of the elbow, VAS pain score during activities of daily living [27], VAS palpation pain score at the lateral epicondyle [13], DASH score [7], and grip strength [22].

We used the Wilcoxon signed-rank test (for continuous variables) and Fisher's exact test (for discrete variables) to compare the preoperative and postoperative variables across the two groups. Statistical analysis was performed using SAS for Windows, version 9.1 (SAS Institute Inc, Cary, NC, USA)

Results

Two years postoperative the mean VAS pain scores were 0.3 points in Group A and 0.4 points in Group B, VAS

Fig. 2A–B (A) The posterior synovial tissue (solid arrow) looked slightly inflammatory. (B) The synovial tissue was removed carefully to save the annular ligament. U = ulnar portion of the proximal radioulnar joint; R = radial head; C = capitellum.

palpation pain scores were 0.9 points and 0.4 points, DASH scores were 5.1 points and 6.1 points, and grip strengths were 57.1 kg and 73.4 kg, respectively (Table 2). VAS pain score, VAS palpation pain score, DASH score, and grip strength were improved at the last followup in both groups (Table 3).

The VAS pain score improved postoperatively in the both groups. Two weeks postoperatively we observed a decrease ($p < 0.001$) in the VAS pain score (Fig. 3). The VAS pain score decreased ($p < 0.001$) gradually the first postoperative year, and thereafter, it remained at a similar level ($p < 0.001$) up to 2 years postoperative in both groups. Although the VAS pain scores diminished more slowly for Group B than for Group A during the first postoperative year, the improvement pattern was similar (Fig. 3). In Group A, two patients (10%) had a VAS pain score greater than 3.0 at 6 months postoperative, however, they all experienced pain relief by the first postoperative year. In nine patients (50%) in Group B, the VAS pain score continued to be greater than 3.0 at 6 months postoperative, showing a slower decrease of the VAS pain score compared with Group A. Seven of the nine patients

Table 3. Summary of major outcome variables

Variable	Group A	Group B
VAS pain score (0–10)		
Preoperative	9.0 (7–10)	9.1 (8–10)
Postoperative (final)	0.3 (0–3)	0.4 (0–3)
p value*	< 0.001	< 0.001
VAS palpation pain score (0–10)		
Preoperative	9.0 (7–10)	9.4 (8–10)
Postoperative (final)	0.9 (0–3)	0.4 (0–5)
p value*	< 0.001	< 0.001
DASH score (0–100)		
Preoperative	54.6 (39.1–79.2)	55.8 (36.6–78.3)
Postoperative (final)	5.1 (0–25.8)	6.1 (0–25.8)
p value*	< 0.001	< 0.001
Grip strength (kg)		
Preoperative	34.3 (10–61)	49.8 (19–91)
Postoperative	57.1 (29–85)	73.4 (32–134)
p value*	< 0.001	< 0.001

* Wilcoxon signed-rank test.

experienced pain relief at the first postoperative year, and the other two (12%) patients experienced pain relief at 2 years postoperative.

There were no surgical complications such as infection, joint contracture, joint instability, or nerve injury.

Discussion

The pathologic features and involved anatomic structures causing lateral epicondylitis remain unclear. The ECRB origin is the commonly accepted source of disease [10, 29]. Other structures such as the annular ligament and lateral capsule also might be causative factors of lateral epicondylitis. Baker et al. [2] described an arthroscopic technique to release the ECRB origin and reported 95% being “much better” or “better” elbow function than preoperative status at followup. Mullett et al. [23] introduced arthroscopic resection of a capsulohyal fold of the leading edge of the annular ligament with the common extensor origin left undisturbed and reported 93% complete relief of symptoms (Table 4). However, it is unclear whether resecting this fold enhances pain relief or function. We therefore: (1) determined whether posterior radiocapitellar synovial plica excision made an additional improvement in pain or function after the Baker technique without decortications for lateral epicondylitis; (2) determined the chronologic changes of VAS pain score after surgery; and (3) determined complications related to the two arthroscopic approaches.

There were some limitations to this study. First, we evaluated the arthroscopic synovial fold excision in the

Fig. 3 The postoperative VAS pain scores decreased progressively until 2 years postoperative in Group A and Group B. All differences in the postoperative followup were $p < 0.001$.

posterior radiocapitellar joint, not in the anterior radiocapitellar joint, which may be somewhat different from the technique originally described by Mullett et al. [23]. However, they described the arthroscopic technique as a synovial fold excision beginning from the posterior radiocapitellar joint mainly to the anterior radiocapitellar joint, therefore, we thought the posterior radiocapitellar synovial plica was an important target of this procedure. Moreover, the posterior radiocapitellar joint approach is difficult or unnecessary from the anterior compartment that is the main area of the Baker technique, therefore, we evaluated the posterior radiocapitellar synovial plica excision in addition to the Baker technique to determine the efficacy and potential time saved with arthroscopy. Second, our study population was relatively small and might not allow the detection of statistical differences between the groups. A properly powered prospective study could be helpful in establishing whether the posterior radiocapitellar synovial plica excision has a place in the treatment of refractory lateral epicondylitis.

We observed no differences between Groups A and B regarding the VAS pain score, VAS palpation pain score, DASH score, and grip strength at 2 years postoperative. Mullett et al. [23] reported 93% complete relief of symptoms using only arthroscopic synovial excision, thus suggesting that the main pathologic features might not be the ECRB or there might be a common healing process that could be activated by a posterior synovial fold excision. Tsuji et al. [30], in their study of the histologic features of the common extensor tendon, suggested the joint capsule and posterior synovial fold might be involved in the pathogenesis of lateral epicondylitis owing to its location near the origin of the ECRB. It sometimes might be necessary to simultaneously treat the posterior synovial fold and joint capsule to achieve symptom improvement in

lateral epicondylitis. Therefore, it is reasonable to believe the Baker technique combined with a posterior synovial fold excision may improve postoperative pain or function scores, because a combined technique can reduce the possibility of neglect of the involved joint capsule and posterior synovial fold. However, our study showed that posterior synovial plica excision did not provide additional improvement in postoperative pain or function score over the Baker technique. Thus our study suggests that refractory lateral epicondylitis can be improved in pain and function by the Baker technique alone. In addition, because the postoperative pain or function scores were not different between the two groups despite the higher incidence of tenderness in the radiohumeral joint in Group A, the preoperative finding of tenderness at the radiohumeral joint could not predict the necessary simultaneous treatment of posterior synovial fold excision.

The major outcome variables including VAS pain score, VAS palpation pain score, DASH score, and grip strength were improved at the last followup. Baker et al. [1, 2] initially recommended decortication to improve healing of the affected ECRB, an arthroscopic modification instead of the drilling used in the open technique. However, before the beginning of this study, we observed that some patients had tenderness and pain at the lateral epicondyle that lasted for a long time postoperatively. As a result, during our study, we did not include the decortication procedure, unlike the original technique with decortication proposed by Baker et al. [2]. They also reported they no longer perform decortication [1] and other authors [16] also concluded that decortication was not necessary because patients undergoing decortication experienced long-lasting pain relief. Our study suggests refractory lateral epicondylitis can be treated appropriately by the Baker technique without decortication.

Table 4. Literature review of outcomes of arthroscopic treatment for lateral epicondylitis

Study	Number of patients	Age of patients (years)	Mean followup (months)	Mean duration of symptoms (months)	Average number of previous steroid injections	Postoperative		Result and complications
						VAS pain score with ADL	Grip strength	
Baker et al. [2]	39	42.7	32	14	2.6	1.5 (of 10)	96% of opposite side	MEP function 11.1 (of 12) 37 (95%) much better or better; no neuroma or elbow instability
Mullett et al. [23]	30	46	NA	NA	NA	24 (80%) no pain	NA	28 (93%) had complete relief of symptoms; no elbow instability
Baker & Baker [1]	42	43	130	NA	NA	1.0 (of 10)	NA	29 (97%) much better or better
Grewal et al. [11]	36	45.3	42	30	2.5	PRTEE 14.6 (of 50)	27.3% improvement	14 (39%) completely asymptomatic, 16 (44%) much better or better
Lattermann et al. [20]	36	42	42	19	2.5	1.9	91% of opposite side	MEP function 11.1 (of 12) One (0.03%) transient subjective forearm paresthesia
Kim et al. [16]	38	46	30	15.4	NA	1.0 (of 10)	12.7 kg	MEP score 95 (of 100) No complications
Current study	38	47	46	14	1.0	0.3 (of 10)	45% improvement	DASH score 5.1 (of 100) No complications

ADL = activities of daily living; NA = not available; MEP = Mayo Clinic Elbow Performance Index; PRTEE = Patient-rated Tennis Elbow Evaluation.

The VAS pain score improved postoperatively in both groups, and the decrease of VAS pain score was noted at 2 weeks postoperative (Fig. 3). Several studies have reported early pain relief and return to work [2, 11, 19, 20] (Table 4). We found most patients returned to their jobs without difficulties approximately 12 weeks postoperatively, taking longer than the 2.2 weeks reported by Baker et al. [2]. Since there appeared to be no major difference in the distribution of the patients' work (heavy manual labor: office-type work) in their study and ours, we cannot explain the reason for the difference. Generally, the progression of pain relief in patients in Group B was slower than that of patients in Group A after 6 weeks postoperative, however a similar pattern was observed after 2 years postoperative. Therefore, we believe that patients who underwent posterior synovial fold excision took longer to achieve a comfortable level of pain status compared with patients who had the Baker procedure.

There were no surgical complications such as infection, joint contracture, joint instability, or nerve injury. Complications related to arthroscopic treatment for lateral epicondylitis, including transient subjective forearm paresthesias (0.03%), have been reported [20].

We found no additional effect of posterior synovial fold excision on the Baker technique without decortication, and believe refractory lateral epicondylitis can be treated appropriately by the Baker technique without decortication.

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References

1. Baker CL Jr, Baker CL 3rd. Long-term follow-up of arthroscopic treatment of lateral epicondylitis. *Am J Sports Med.* 2008;36:254–260.
2. Baker CL Jr, Murphy KP, Gottlob CA, Curd DT. Arthroscopic classification and treatment of lateral epicondylitis: two-year clinical results. *J Shoulder Elbow Surg.* 2000;9:475–482.
3. Baumgard SH, Schwartz DR. Percutaneous release of the epicondylar muscles for humeral epicondylitis. *Am J Sports Med.* 1982;10:233–236.
4. Boyd HB, McLeod AC Jr. Tennis elbow. *J Bone Joint Surg Am.* 1973;55:1183–1187.
5. Boyer MI, Hastings H 2nd. Lateral tennis elbow: "Is there any science out there?". *J Shoulder Elbow Surg.* 1999;8:481–491.
6. Coonrad RW, Hooper WR. Tennis elbow: its course, natural history, nonoperative and surgical management. *J Bone Joint Surg Am.* 1973;55:1177–1182.
7. Dawson J, Doll H, Boller I, Fitzpatrick R, Little C, Rees J, Jenkinson C, Carr AJ. The development and validation of a patient-reported questionnaire to assess outcomes of elbow surgery. *J Bone Joint Surg Br.* 2008;90:466–473.
8. Gardner RC. Tennis elbow: diagnosis, pathology and treatment. Nine severe cases treated by a new reconstructive operation. *Clin Orthop Relat Res.* 1970;72:248–253.
9. Goldberg EJ, Abraham E, Siegel I. The surgical treatment of chronic lateral humeral epicondylitis by common extensor release. *Clin Orthop Relat Res.* 1988;233:208–212.
10. Goldie I. Epicondylitis lateralis humeri (epicondylalgia or tennis elbow): a pathogenetical study. *Acta Chir Scand Suppl.* 1964;57(suppl 339):1.
11. Grewal R, MacDermid JC, Shah P, King GJ. Functional outcome of arthroscopic extensor carpi radialis brevis tendon release in chronic lateral epicondylitis. *J Hand Surg Am.* 2009;34:849–857.
12. Hall MP, Band PA, Meislin RJ, Jazrawi LM, Cardone DA. Platelet-rich plasma: current concepts and application in sports medicine. *J Am Acad Orthop Surg.* 2009;17:602–608.
13. Harms-Ringdahl K, Carlsson AM, Ekholm J, Raustorp A, Svensson T, Toresson HG. Pain assessment with different intensity scales in response to loading of joint structures. *Pain.* 1986;27:401–411.
14. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG). *Am J Ind Med.* 1996;29:602–608.
15. Keizer SB, Rutten HP, Pilot P, Morre HH, v Os JJ, Verburg AD. Botulinum toxin injection versus surgical treatment for tennis elbow: a randomized pilot study. *Clin Orthop Relat Res.* 2002;401:125–131.
16. Kim JW, Chun CH, Shim DM, Kim TK, Kweon SH, Kang HJ, Bae KH. Arthroscopic treatment of lateral epicondylitis: comparison of the outcome of ECRB release with and without decortication. *Knee Surg Sports Traumatol Arthrosc.* 2011;19:1178–1183.
17. Ko JY, Chen HS, Chen LM. Treatment of lateral epicondylitis of the elbow with shock waves. *Clin Orthop Relat Res.* 2001;387:60–67.
18. Kraushaar BS, Nirschl RP. Tendinosis of the elbow (tennis elbow): clinical features and findings of histological, immunohistochemical, and electron microscopy studies. *J Bone Joint Surg Am.* 1999;81:259–278.
19. Kuklo TR, Taylor KF, Murphy KP, Islinger RB, Heekin RD, Baker CL Jr. Arthroscopic release for lateral epicondylitis: a cadaveric model. *Arthroscopy.* 1999;15:259–264.
20. Lattermann C, Romeo AA, Anbari A, Meininger AK, McCarty LP, Cole BJ, Cohen MS. Arthroscopic debridement of the extensor carpi radialis brevis for recalcitrant lateral epicondylitis. *J Shoulder Elbow Surg.* 2010;19:651–656.
21. Maffulli N, Regine R, Carrillo F, Capasso G, Minelli S. Tennis elbow: an ultrasonographic study in tennis players. *Br J Sports Med.* 1990;24:151–155.
22. Mathiowetz V, Weber K, Volland G, Kashman N. Reliability and validity of grip and pinch strength evaluations. *J Hand Surg Am.* 1984;9:222–226.
23. Mullett H, Sprague M, Brown G, Hausman M. Arthroscopic treatment of lateral epicondylitis: clinical and cadaveric studies. *Clin Orthop Relat Res.* 2005;439:123–128.
24. Nirschl RP, Pettrone FA. Tennis elbow: the surgical treatment of lateral epicondylitis. *J Bone Joint Surg Am.* 1979;61:832–839.
25. Owens BD, Murphy KP, Kuklo TR. Arthroscopic release for lateral epicondylitis. *Arthroscopy.* 2001;17:582–587.
26. Posch JN, Goldberg VM, Larrey R. Extensor fasciotomy for tennis elbow: a long-term follow-up study. *Clin Orthop Relat Res.* 1978;135:179–182.
27. Price DD, McGrath PA, Rafii A, Buckingham B. The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. *Pain.* 1983;17:45–56.
28. Rajeev A, Pooley J. Lateral compartment cartilage changes and lateral elbow pain. *Acta Orthop Belg.* 2009;75:37–40.
29. Regan W, Wold LE, Coonrad R, Morrey BF. Microscopic histopathology of chronic refractory lateral epicondylitis. *Am J Sports Med.* 1992;20:746–749.
30. Tsuji H, Wada T, Oda T, Iba K, Aoki M, Murakami G, Yamashita T. Arthroscopic, macroscopic, and microscopic anatomy of the synovial fold of the elbow joint in correlation with the common extensor origin. *Arthroscopy.* 2008;24:34–38.