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SECTION II
ORIGINAL ARTICLES

Arthroscopic Treatment for Limitation of Motion of the Elbow

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This study describes the long-term clinical results and serial changes of postoperative range of motion after arthroscopic treatment for limitation of motion of the elbow. Sixty-three patients with limitation of motion of the elbow were treated with arthroscopic procedures. The total range of motion was 79° before surgery. The range of motion showed a progressive increase until 1 year after surgery (mean, 121°). However, after 1 year, the range of motion showed little additional increase. The range of motion acquired during surgery (mean, 122°) usually was the same range that patients achieved during the rehabilitation period (mean, 122° at an average 42.5 months of followup). Extension improved an average of 21°, and flexion increased an average of 23°. The range of motion showed more improvement in patients whose duration of symptoms was less than 1 year (49°) than in those whose duration of symptoms was longer than 1 year (30°). Patients with posttraumatic stiffness had more marked limitation of extension and decreased total range of motion (73°) than did those with degenerative stiffness (86°) before surgery. However, no significant difference existed in the postoperative total range of motion (posttraumatic stiffness, 123°; and degenerative stiffness, 121°). Based on the authors' experience, 92% of patients obtained significant improvement in range of motion after arthroscopic procedures. The minimally invasive nature of elbow arthroscopy is a reproducible and effective procedure for limitation of motion of the elbow with minimal morbidity.

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Although the normal range of flexion to extension of the elbow is from 0° to 145°, most daily activities can be accomplished without discomfort within the functional range of 100° (range, 30°–130°) elbow flexion.[12] Loss of motion of the elbow beyond the functional

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range poses a serious problem functionally and cosmetically because the elbow serves as the fundamental link between the shoulder and hand. In addition, the elbow provides power for lifting and stability for precision tasks. Consequently, restoration of the normal range of motion (ROM) in a stiff elbow is a major concern, and various surgical techniques have been attempted to resolve this problem.[3,9,11,13,19] Since the late 1980s, an arthroscopic procedure has been used successfully for diagnosis and treatment of symptomatic elbows. However, because arthroscopic intervention of the elbow is technically difficult and riskier than arthroscopy of larger joints, the procedure has not been used as widely and its effectiveness is not as well documented. This study describes the long-term clinical results and serial changes of postoperative ROM after arthroscopic treatment for limitation of motion of the elbow.

MATERIALS AND METHODS

From July 1990 to February 1997, 88 patients with limitation of motion of the elbow were treated with arthroscopic procedures. Thirteen patients with arthrofibrosis of the elbow caused by inflammatory diseases, such as rheumatoid arthritis and tuberculous arthritis, were excluded. Twelve patients were lost to followup, and 63 patients were available for the minimum followup of 2 years. There were 53 male and 10 female patients. The average age at the time of surgery was 34.2 years (range, 11-61 years). The interval from the onset of symptoms to arthroscopic treatment ranged from 3 months to 18 years (average, 38.3 months; median, 15 months). The two most common causes of limitation of motion of the elbow were posttraumatic and degenerative stiffness. There were 33 (52%) patients with stiffness caused by trauma, including traffic accidents, falls, and sports injuries. Thirty (48%) patients had contractures caused by degenerative arthritis, including overuse injuries. The dominant arm was involved in 14 (42%) patients with posttraumatic stiffness and in 23 (77%) patients with degenerative stiffness (Table 1).

Among 33 patients with trauma as the etiology, the cause of injury was a fall for 16 patients, sports injury for nine, and traffic accident for eight. Twenty-five patients had fractures around the elbow, six patients had an isolated elbow dislocation, and two patients had a fracture with dislocation. The fractures around the elbow included 13 radial head fractures, seven supracondylar fractures, five olecranon fractures, and two humeral condyle fractures. Thirteen of 33 patients with posttraumatic stiffness had undergone previous surgical procedures for fractures around the elbow. Among 30 patients with no history of trauma (degenerative arthritis), 20 had occupations or avocations that involved repetitive use of the arms, including 11 manual laborers and nine athletes.

All patients undergoing treatment for limitation of motion of the elbow received physical therapy before consideration for surgery. Arthroscopic surgery was indicated when restricted elbow motion disturbed daily activities and when ROM did not improve, despite initial treatment by physical therapy for at least 3 months. Anterior capsular release was performed in patients who had extension limitation greater than 30°. The senior author (S-JK) performed the arthroscopic surgery on all patients. Clinical followup was done regularly at 1 or 2 weeks, 3 months, 6 months, 1 year, and every subsequent year after surgery. The average final followup interval was 42.5 months (range, 24-90 months). All patients responded to a questionnaire about subjective satisfaction with the surgery, and clinical outcomes were examined regularly in the outpatient department during followup. The range of elbow motion was evaluated by a goniometer. Statistical analysis was applied using the Student's t test and paired t test.

TABLE 1. Clinical Characteristics of the Patients With Posttraumatic and Degenerative Stiffness

Demographic	Posttraumatic	Degenerative
Age (years)	32.1	35.3
Gender (M:F)	27:6	26:4
Symptom duration (months)	21.1	14.6
Dominant elbow (number)	14(42%)*	23(77%)*

* significant difference ($p < 0.05$).

Surgical Technique and Arthroscopic Findings

Under general anesthesia, the patients were placed in a prone position. Using a pneumatic tourniquet, the involved arm was brought to the edge of the operating table with the forearm hanging freely and the elbow flexed to 90°. The joint was distended with 10 to 20 mL saline through the direct lateral portal. Standard anterolateral, anteromedial, posterolateral, and posterior portals were used in all patients. If necessary, the proximal medial portal and other accessory portals were used.

The anterolateral portal was established for initial entry of the arthroscope. The anterolateral portal is identified 2 cm distal and 2 cm anterior to the lateral humeral epicondyle. This point is just anterior and proximal to the radial head, which can be palpated easily by pronating and supinating the forearm. When establishing the anterolateral portal, the arthroscope may pass 4 mm (range, 3–7 mm) beneath the radial nerve, and the posterior antebrachial cutaneous nerve also is in proximity, with a mean distance of 2 mm from the portal.[5] The anteromedial portal, which lies 2 cm anterior and 2 cm distal to the medial humeral epicondyle, was made using an inside-out technique with a Wissinger rod. The medial antebrachial cutaneous nerve is at risk when establishing the anteromedial portal. Through these portals, arthroscopic procedures were performed with a small joint arthroscope (2.7-mm diameter, 30° angulation) in the anterior compartment. For inspection of the posterior compartment of the joint, the posterolateral portal was used as the entry portal. The posterolateral portal is established approximately 3 cm proximal to the tip of the olecranon near the lateral margin of the triceps. The posterior antebrachial cutaneous nerve and the lateral brachial cutaneous nerve are the closest cutaneous nerves. An additional straight posterior portal (2 cm medial to the posterolateral portal) through the triceps tendon was used for access of the instrumentation. To avoid injury to the nerves, the joint is maximally distended and a small incision is made in the skin only with a Number 11 blade. The underlying subcutaneous tissues were deepened by using a hemostat before introduction of the arthroscopic instruments.

The surgical procedures depended on the intra-articular findings. If the joint was difficult to visualize because of extensive scarring and hypertrophic synovium, the soft tissue covering the compartment was debrided using a full radius resector. Once the joint could be visualized, attention turned to the osseous structures to locate loose bodies or osteophytes. The smallest loose bodies were extracted first. Localized osteochondral lesions were treated by debriding the articular surface with a high speed burr and full radius resector or drilling. In the anterior compartment, if the coronoid process or distal humerus had prominent osteophytes preventing full flexion, the osteophytes were excised using an osteotome or motorized burr. After bony impingement was relieved, the anterior capsule was inspected. A tightened anterior capsule was divided transversely under direct view to protect neurovascular structures until the posterior fibers of the brachialis muscles were identified proximally. Complete release of the tightened capsule using a combination of full radius resector and retrograde knife was necessary to regain acceptable ROM (Fig 1).

In the posterior compartment, scar tissue around the olecranon fossa and posterior capsule was removed through the straight posterior portal to improve visibility. When the arm was extended under arthroscopic visualization, any osteophytes creating impingement at the olecranon tip or in the posterior olecranon fossa were resected using a motorized burr (Fig 2). If any ingrown bony hypertrophy or loose bodies that limited the ROM were found in the olecranon fossa, it debrided and deepened if

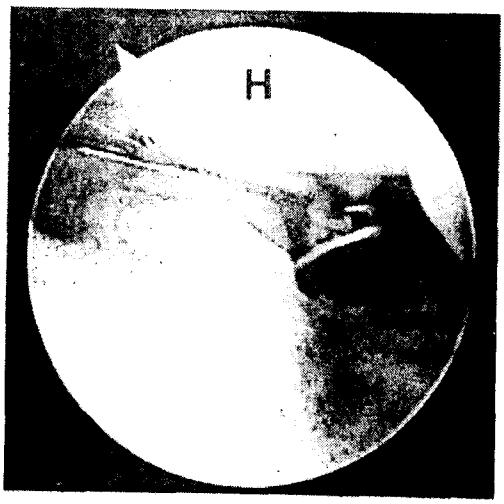

Fig 1. The anterior capsule is divided transversely from the medial to the lateral side using a retrograde knife at the proximal third level. H = distal humeral condyle.

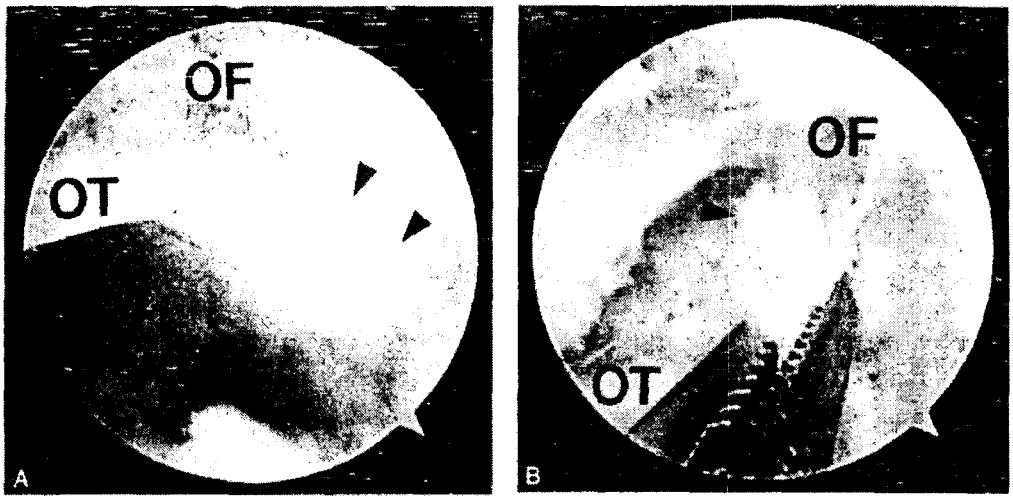

Fig 2A–B. (A) In the posterior compartment, osteophytes (arrowheads) creating impingement at the olecranon tip are resected by an osteotome through the straight posterior portal. (B) The osteophytes (arrowhead) are removed by the grasper from the olecranon tip. OF = olecranon fossa; OT = olecranon tip.

necessary. Active and gentle passive ROM exercises were begun as soon as pain and swelling had subsided after surgery. In patients with a marked limitation of motion before surgery, continuous passive motion exercises were used during postoperative physiotherapy for 1 week.

RESULTS

As a preoperative symptom, 40 (63%) patients had pain with limitation of motion. Fifteen (45%) patients had posttraumatic stiffness and 25 (83%) patients had degenerative stiffness. Twenty-three (37%) patients had only limitation of motion of the elbow as a preoperative symptom. Overall, five (8%) patients still had occasional mild pain after the operation. The intraarticular main pathologic features of limitation of elbow motion were fibrous tissue adhesion in 42 patients, loose bodies in 35, and osteophytes in 33. The average number of loose bodies found in one joint was 1.3 (posttraumatic stiffness, 0.6; degenerative stiffness, 2.0). The most frequent predilection site of osteophytes was the coronoid process (15 patients), followed by the olecranon tip in 11, olecranon fossa in 10, and anterior portion of distal humerus in six patients.

Among 63 patients, 58 (92%) achieved more than 10° total ROM after surgery and had statistically significant improvements between the preoperative and postoperative values ($p = 0.001$). Fifty-seven (90%) patients had improved motion in flexion after surgery, and 55 (87%) had improved motion in extension after surgery. The preoperative mean extension of 29° (range, 0°–65°) improved to 9° (range, 0°–35°) after surgery. Flexion increased from an average of 108° (range, 60°–135°) before surgery to 131° (range, 100°–145°) after surgery (Table 2). The mean ROM was 79° before surgery, which markedly increased to 121° immediately after the arthroscopic procedures while the patients were still under general anesthesia in the operating room. However, the mean ROM quickly was lost during the first and second postoperative weeks (average, 101°), mainly because of pain and swelling. The ROM then increased progressively until 6 months after surgery (mean, 109° at 3 months; mean, 118° at 6 months). One year after surgery, the mean ROM had increased

TABLE 2. Clinical Results After Arthroscopic Management

Clinical Variable	Posttraumatic *Preoperative/Postoperative*	Degenerative *Preoperative/Postoperative*
Pain (Number)	15 (45%)*/2 (6%)	25 (83%)*/3 (6%)
Loose body	0/6	2/0
Anterior capsular release (%)	22 (67%)	10 (33%)
Extension (°)	33/9	25/8
Flexion (°)	106/132	110/129
Total range of motion (°)	73°/123	85°/121

* significant differences ($p < 0.05$)

nearly to the intraoperative ROM (average, 121°). There was no significant change in the mean ROM checked at 1 year after surgery and at the last followup. The total ROM was a mean of 122° at an average 42.5 months of followup (Fig 3).

The duration of symptoms was significantly correlated with the postoperative improvements in ROM ($p < 0.05$). Patients who had limitation of motion for less than 1 year gained an average 49° improvement in total ROM after arthroscopic surgery. The total ROM in patients with duration of symptoms greater than 1 year improved by an average 30° after surgery (Fig 4).

Forty-nine patients had no functional arc of motion (30°-130°) before surgery, but 44 (90%) patients achieved that motion after arthroscopic treatment. Four patients had no improvement in postoperative ROM. Although they obtained slight improvement in the ROM in the operating room, the contracture recurred during the rehabilitation period. Two of the four patients had degenerative stiffness for a long duration (15 years and 18 years, respectively) and showed severe cartilage degenerative changes in arthroscopic findings. The third patient had stiffness caused by radial head fracture and dislocation for 3 years and had severe periarticular contractures. The fourth patient had posttraumatic stiffness and adhesions surrounding the triceps muscle for 18 months after supracondylar fracture.

Patients with posttraumatic stiffness had more marked limitation of extension than did those with degenerative stiffness before surgery (33° and 25°, respectively). How-

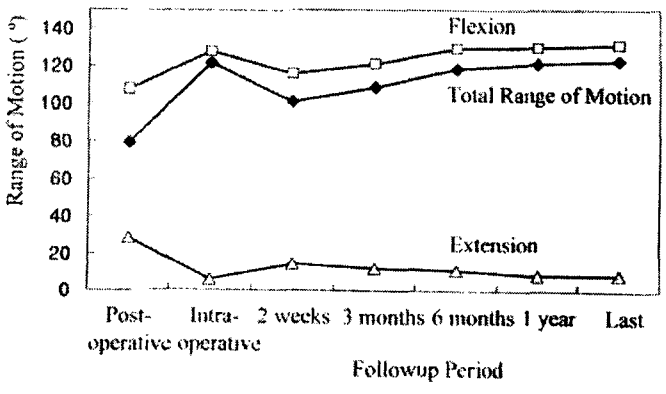

Fig 3. Serial changes of postoperative ROM.

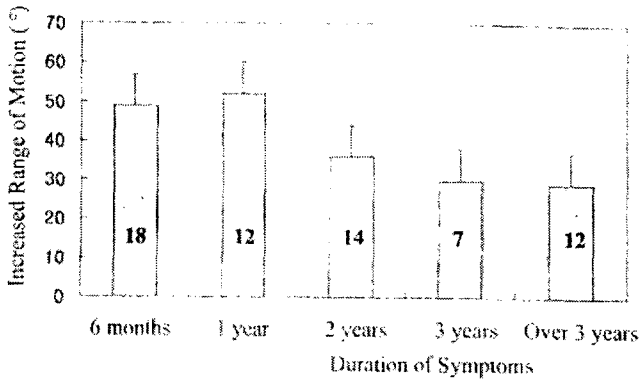

Fig 4. Improvement of total ROM according to duration of symptom. *Numbers in the bars represent the number of patients.

ever, patients with posttraumatic stiffness had more improvement in extension after surgery. At the last followup, the average improvement in extension was 24° for patients with posttraumatic stiffness compared with 17° for patients with degenerative stiffness. The total ROM for patients with posttraumatic stiffness improved from a preoperative mean of 73° to a postoperative mean of 123°, whereas patients with degenerative stiffness improved from a preoperative mean of 86° to a postoperative mean of 121°. Although there was a statistically significant difference in the preoperative mean ROM between the two groups, no significant differences existed in the postoperative ROM at the last followup. Among 33 patients with posttraumatic stiffness, previous operations for fractures around the elbow did not affect the final total ROM. Total ROM at the last followup averaged 124° in the previous operative group (13 cases) and 122° in the group previously undergoing conservative treatment (20 cases).

Anterior capsular release was performed in 22 (67%) patients with posttraumatic stiffness and in 10 (33%) patients with degenerative stiffness. The total ROM in patients who received anterior capsular release increased from 75° before surgery to 120° after surgery (Table 3). The total ROM in patients who received treatments other than anterior capsular release increased from 85° before surgery to 125° after surgery. The improvement in extension in patients who received anterior capsular release (23°) was greater than in the group who did not receive anterior capsular release (15°). However, there was no significant difference in the increase of flexion between the two groups (21° and 25°, respectively).

Overall, 59 patients were satisfied with the surgery. Even in the four (6%) patients whose ROM did not improve markedly after surgery, the pain subsided after the arthroscopic proce-

TABLE 3. Range of Motion of the Elbow According to Anterior Capsular Release

Range of Motion	Anterior Capsular Release	
	Yes *Preoperative/Postoperative*	*No* *Preoperative/Postoperative*
Extension (°)	31/11	22/7
Flexion (°)	103/130	107/132
Total range of motion (°)	75*/120	85*/125

* significant differences ($p < 0.05$).

dures. In two patients, transient median nerve palsy occurred immediately after the operation. The complications occurred in patients with large loose bodies that were removed with difficulty. The transient median nerve palsy recovered completely 4 weeks after the operation without any surgical intervention.

DISCUSSION

As a result of its specific anatomy and potential for serious injury, the elbow, more than any other joint, is prone to have stiffness develop. Morrey[11] suggested that the predisposing factors of stiffness in the elbow included the close interrelationship of the joint capsule with extracapsular muscles, the high degree of congruency of the joint, and the somewhat unique response of the joint capsule to trauma.

Some contractures of short duration and little evidence of intraarticular damage may respond to conservative treatment.[11] However, surgical management of a stiff elbow is considered between 6 months and 1 year after conservative treatment has failed. Open procedures, including open arthrotomy with or without anterior capsulotomy and distraction arthroplasty, have been used, and good functional results have been obtained.[9,11,17] However, open procedures require extensive dissection and muscle splitting, which may cause difficulties for the patient in rehabilitation during the immediate postoperative period. Conversely, elbow arthroscopy provides the benefits of less surgical morbidity and the ability to start physical therapy more comfortably soon after the operation.[6,7,15,20] In addition, arthroscopy allows improved visualization of intraarticular structures and more appropriate debridement of all compartments of the elbow.

Although arthroscopy of the elbow technically is demanding and risky because the portals are located relatively close to vital neurovascular structures, serious complications can be avoided with thorough knowledge of the intraarticular anatomy of the elbow and proficiency in technique. The limitation of motion of the elbow with intrinsic causes, such as loose bodies, osteophytes, and intraarticular scar adhesions, and those with extrinsic causes that may be reached safely by arthroscopic technique including capsular contractures may be good candidates for arthroscopic management. However, causes of contractures that cannot be reached from within the joint are not amenable to arthroscopy. Limitation of motion secondary to muscle spasticity, cerebral palsy, burn scar contracture, and heterotopic ossification may require open procedures.

Satisfactory results of arthroscopy for elbow stiffness have been reported.[3,6,7,13] Phillips and Strasburger[13] reported an average 41° increase in total ROM in 25 patients with arthritis. Timmerman and Andrews[18] obtained increased ROM in 84% of patients with posttraumatic elbow stiffness. In this study, 92% of patients overall had significant improvement in elbow ROM (average, 44°) through arthroscopic procedures. The ROM acquired during surgery, while patients were still under general anesthesia, usually was in the same range that patients achieved during the rehabilitation period. From 1 to 2 weeks after the operation, the ROM decreased from that observed in the operating room because of postoperative pain and swelling. After that, the ROM began to increase with continuous postoperative physical therapy and showed a progressive increase between the first and sixth months after surgery. The ROM continued to increase slowly until 1 year after surgery. However, by 1 year after surgery, the ROM showed little additional increase. Almost the same ROM was observed at the last followup. The changes of total ROM at each followup showed a similar pattern in patients with posttraumatic and degenerative stiffness. It seemed that no statistical relationship between the etiology of elbow stiffness and recovery after surgery could be found.

Loss of terminal extension is less disabling than loss of the same degree of terminal flexion because the restoration of flexion is necessary to perform daily activities such as eating and hair combing. In this study, extension improved an average of 21° and flexion increased an average of 23°. Although the improvement

in flexion was greater than the improvement in extension, patients in general showed more appreciation for improvement in extension. The authors think this may be because the elbow looked better in a less flexed posture at the side.

The clinical results varied according to the optimal operation time, underlying disease, and appropriate treatment. The authors obtained marked improvement in patients whose duration of symptoms was less than 1 year. The restoration of ROM in patients with symptoms greater than 1 year was less favorable. It seemed the optimal time for arthroscopic surgery in limitation of motion of the elbow was less than 1 year after the development of symptoms. In this study, patients with posttraumatic stiffness had more marked limitation of extension and decreased total ROM than did those with degenerative stiffness before surgery. However, patients with posttraumatic stiffness had larger gains in ROM after the operation.

In contrast to the series of Urbaniak et al,[19] the authors of the current study found no differences in the results of patients with posttraumatic arthrosis compared with patients with nontraumatic etiology of contracture at the latest followup. This is because patients with posttraumatic stiffness had a shorter duration of symptoms and were treated more constructively (anterior capsular release) than were those with degenerative stiffness. Of particular importance was the primary involvement of the dominant arm in patients with degenerative stiffness. This predisposition probably was attributable to repetitive microtrauma. The number of loose bodies also was higher in patients with degenerative stiffness. Most loose bodies were found with osteophytes in the degenerative joint.

Ogilvie-Harris et al[14] reported the importance of procedures in the posterior compartment of the elbow to restore normal ROM, especially full extension. The olecranon tip is subjected to repetitive impingement when weight lifters lock out the elbow in extension and when throwing athletes reach terminal extension. As a result, osteophyte lipping of the olecranon and reduction in the depth of olecranon fossae contributed to posterior impingement and a decrease in elbow movement. The authors routinely investigated the posterior compartment of every stiff elbow. In addition to posterior impingement, full extension is restricted by anterior scarring if the capsule has adhered to the distal humerus. Several studies have reported that it was difficult to improve the ROM by simple release of intraarticular adhesions without anterior capsular release.[4,5,13,18] In the current study, anterior capsular release was performed in patients who had limitation of extension greater than 30°. Because patients with posttraumatic stiffness had more marked limitation of extension, anterior capsular release was performed more frequently in patients with posttraumatic stiffness than in patients with degenerative stiffness. Significant improvement in extension with anterior capsular release was obtained.

Gallay et al[5] reported that capsular compliance of the stiff elbow is only 15% of the normal elbow. With a stiff elbow, adequate capsular distention is not attainable, which increases the potential for nerve injury with the use of the portals.[8,9,16] To avoid complications, the portals should be placed as close as possible to the joint articulation with the elbow flexed at 90°, and forceful manipulation during the introduction of instrumentation should be avoided. Attention also must be given to correct the forearm position and to be aware of the location of anatomic structures, which may have shifted after previous elbow surgery or trauma.[1]

Complications that can occur after arthroscopic treatment of stiff elbows are similar to those encountered after other arthroscopic procedures, but most complications are neurovascular in nature. However, the reported neurologic complications were rare in regard to anatomic conditions of stiff elbows.[6,14,15] Phillips and Strasburger[15] and Timmerman and Andrews[18] reported no neurologic complications after arthroscopic procedures. Jones and Savoie[6] reported one posterior interosseous nerve palsy among 12 stiff elbows. In the current series, there

were two transient median nerve palsies with no other serious complications.

Based on the experience of the authors of the current study, 92% of patients obtained significant improvement in ROM. The ROM improved progressively during the first 6 months and then slowly for 1 year. The optimal time for arthroscopic surgery was less than 1 year after development of symptoms. The minimally invasive nature of elbow arthroscopy is a reproducible and effective procedure in limitation of motion of the elbow with minimal morbidity.

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