The purpose of this study was to compare outcomes and complications of clavicular hook plate and Kirschner tension band wiring for fixation of unstable lateral clavicle fractures. The surgical outcomes of 92 consecutive patients (mean age, 49.30±15.54 years) with unstable fractures of the lateral clavicle treated using AO clavicle hook plates were compared with those of 24 patients (mean age, 50.67±17.58 years) treated using K-wire tension banding. Patients in the hook plate and K-wire groups were followed up for 22.76±2.22 and 25.67±2.75 months, respectively (\(P<.001\)). The time to hardware removal was significantly shorter (\(P<.001\)) in the hook plate group (5.20±1.93 months) compared with the K-wire group (7.58±2.00 months), whereas the Constant-Murley score was significantly higher (\(P<.001\)) in the hook plate group (90.43±4.78) compared with the K-wire group (85.63±5.38) at final follow-up. There were 12 complications in the hook plate group and 7 in the K-wire group (\(P=.069\)). Complications in the hook plate group included 7 periprosthetic fractures, 4 plate removals, and 1 plate malposition. Complications in the K-wire group included 3 K-wire migrations, 3 losses of reduction, and 1 wire breakage. We found that hook plate fixation of unstable lateral clavicle fractures was associated with statistically better shoulder function and earlier implant removal than K-wire tension band fixation, with an equivalent rate of complications. Our findings suggest that hook plates are useful for treating unstable lateral clavicular fractures.

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Unstable lateral clavicle fractures (Neer type II) are usually associated with a high risk of delayed union, malunion, and nonunion. Malunion can cause not only cosmetic problems but also shortening and improper angulations, leading to glenohumeral and scapulothoracic joint dysfunction, as well as subacromial impingement. Recent studies have identified a higher rate of nonunion and specific deficits of shoulder function from lateral clavicle fractures, where each injury requires careful assessment and individualized treatment.

Nonoperative treatment of unstable lateral clavicle fractures can lead to a high incidence (22%-30%) of pseudoarthrosis. Although surgical fixation is recommended as the treatment of choice, no consensus exists on the ideal fixation method. Several fixation methods such as Kirschner wire (K-wire), with or without tension band wiring, Knowles pin, AO hook plate, and plate fixation have been reported. K-wire fixation alone was reported to be associated with an unacceptably high rate of complications, such as wire breakdown or migration.

Hook plate fixation appears to be a valuable method of stabilizing Neer type II lateral clavicle fractures, resulting in high union rates and good shoulder function. These plates need to be removed after union to prevent acromial osteolysis. Although plate fixation appears ideal for Neer type II fractures, the distal bone fragment is usually small and fragile, making fixation with traditional plates very difficult and insecure. Therefore, the AO hook plate has been designed with an extension hook under the acromion to provide more stable fixation. However, serious complications from the AO plate including subacromial hook impingement and pathologic acromial fractures require attention. Presently, only a few papers report a small series of clinical results using the AO hook plate for lateral clavicle fracture fixation.

Starting in January 2007, we retrospectively reviewed the results of using clavicular hook plate and K-wire tension banding wire fixation in the treatment of unstable lateral clavicle fractures (Neer type II). The purpose of our retrospective observational study was to compare clavicular hook plate and K-wire tension banding wire fixation through the analysis of the complications and functional recovery of the study participants.

MATERIALS AND METHODS

This retrospective observational study (level of evidence, II-2) was approved by the institutional review board of our institution. All our patients with unstable Neer type II lateral clavicle fractures were operated on in our institute from January 2007 to July 2010. The included participants received either K-wire tension band or hook plate operations. Patients lost to postoperative follow-up with acromioclavicular joint dislocation, pathologic fractures, previous surgery on the affected clavicle or shoulder, and incomplete data were excluded. Ninety-two patients received clavicular hook plate (Synthes, West Chester, Pennsylvania) fixation, and 24 patients included. Ninety-two patients received clavicular hook plate (Synthes, West Chester, Pennsylvania) fixation, and 24 patients underwent hook plate or K-wire treatment based on the clinician preference.

The operations were performed by 1 of 6 operating surgeons (K.W., C.H.C.) in the hospital. All surgeons were experienced in the use of hook plates. Seven patients were lost to postoperative follow-up. Among this group, 5 patients were from the hook plate group and 2 were from the K-wire group. The patients underwent hook plate or K-wire treatment based on the clinician preference.

Plain anteroposterior radiographs were used to evaluate bone union every 4 weeks. Radiographs were interpreted by the attending surgeons for both fracture healing status and implant position. Radiographic union was defined as either a bridging callus over the fracture sites or a fracture gap obliteration. Bony union was confirmed by at least 2 orthopedic surgeons who did not participate in the operation. Hardware removal was arranged immediately after noting bony union. At the last follow-up, shoulder function was evaluated with the Constant-Murley scoring system, which comprised activities of daily living (20 points), shoulder movement (40 points), strength (25 points), and pain assessment (15 points), for a 100-point maximum.

Clavicular Hook Plate Fixation

Ninety-two patients with unstable fractures of the lateral clavicle were treated with clavicular hook plate fixation. Fifty-five men and 37 women had a mean age of 49.3 ± 15.54 years (range, 22-80 years). Injuries were caused by motor vehicles in 60 patients, bicycle accidents in 14, falls in 10, and sports injuries in 8.

Each patient was put in the beach-chair position for general anesthesia, and the lateral end of the clavicle and acromioclavicular joint were exposed through a longitudinal skin incision. The clavicle fracture fragments were reduced into correct alignment manually and held in place temporarily by reduction clamps or K-wires. After fracture reduction, a tunnel was made in the subacromial space behind the acromioclavicular joint. The plate was bent to fit the clavicle anatomy if necessary. The hook was then inserted into this tunnel, and the plate was fixed on the medial side of the fracture with regular AO 3.5-mm cortex screws (Figure 1). The operated arm was supported with a sling postoperatively. Immediate mobilization was allowed on the first postoperative day. Pendulum exercises were performed by the patient on the second postoperative day if tolerable. The sling was used for 2 to 3 weeks to provide further protection. Heavy manual work and full range of joint motion were not allowed before implant removal. Patients did not receive specific physiotherapy.
K-wire Tension Band Wiring Fixation

Twenty-four patients with unstable lateral clavicle fractures were treated with K-wire tension band wiring. Seventeen men and 7 women had an average age of 50 years (range, 19-78 years). Injuries were caused by motor vehicle accidents in 18 patients, bicycle accidents in 3, and falls in 3. All patients were placed in the beach chair position, and a standard surgical approach was used for treating the lateral end of the clavicle. After the reduction of fractures, K-wires were transarticularly inserted through the acromioclavicular joint, and additional tension band wiring was used to increase stability (Figure 2). All K-wires were bent to prevent forward migration. The operated arm was supported postoperatively with a sling, usually for 4 to 6 weeks.

Passive mobilization was allowed after 2 to 4 weeks postoperatively as tolerated by the patient. Heavy manual work and full range of motion were not allowed before implant removal. Patients did not receive specific physiotherapy.

Statistical Analysis

Independent 2-sample t tests compared continuous variables and Fisher’s exact tests compared categorical variables between the hook plate fixation and K-wire fixation groups. Continuous variables were presented as mean±standard deviations, while categorical data were represented by a both a number and a percentage. All statistical assessments were 2-sided and evaluated at the .05 level of significance. Statistical analyses were performed using SPSS 15.0 statistical software (SPSS Inc, Chicago, Illinois).

RESULTS

We retrospectively studied unstable lateral clavicle fractures from patients treated at our institution between January 2007 and July 2010. Demographic results are seen in Table 1. No statistically significant difference in age (P=.711), sex distribution (P=.320), and type of injury (P=.561) existed between the hook plate and K-wire groups.

Table 2 compares clinical outcomes between the hook plate fixation and K-wire fixation groups. Significant differences existed in the plate removal time, Constant-Murley score, and follow-up duration between the 2 groups (all P<.001). The average time for plate removal was statistically shorter in the hook plate fixation group than in the K-wire fixation group (5.2±1.96 months vs 7.6±2.00 months, respectively) (P<.001). In the
hook plate fixation group, the mean Constant-Murley score at final follow-up was significantly higher than that in the K-wire fixation group (90.4 ± 4.78 vs 85.6 ± 0.38, respectively) \((P < .001)\). In addition, the follow-up period in the hook plate fixation group (22.76 ± 2.22 months; range, 20-28 months) \((P < .001)\) was significantly shorter than that in the K-wire tension band wiring group (25.67 ± 2.75 months; range, 22-36 months) \((P < .001)\).

Figure 1 shows a radiographic hook plate surgery series where open reduction and internal fixation was performed. The hook was inserted into the subacromial space. Four months postoperatively, a bony union was present. Figure 2 shows a successful radiographic representation of K-wire fixation surgery where an open reduction was performed and a fixation was done with Kirschner tension band wiring. At 5 months postoperatively, the patient had a bony union and a near total recovery of left shoulder function.

Twelve complications occurred in the hook plate fixation group, including 1 plate malposition where the hook was not inserted into the subacromial space (Figure 3), 7 periprosthetic fractures, and 4 plate removals. Seven complications occurred in the K-wire group, including 3 K-wire migrations, 1 wire breakage, and 3 losses of reduction. The difference in complication rates did not meet statistical

| Table 1
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<th>Patient Demographics</th>
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*Independent 2-sample \(t\) test.

| Table 2
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<th>Comparison of Outcomes Between the 2 Groups</th>
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*Independent 2-sample \(t\) test.

\(^a\)Significant difference between the 2 groups: \(P < .05\).

\(^b\)Fisher’s exact test.

Figure 3: Plain radiograph of a right lateral clavicle fracture sustained by a 50-year-old man in a traffic accident (A). Open reduction and internal fixation was performed with a hook plate. Malposition of the hook plate was noted after the first operation, as the hook was inserted into soft tissue instead of the subacromial space (arrow) (B). Subsequently, revised fracture fixation was performed. There is a wide space (arrow) between the hook and acromion undersurface, implicating an impingement into the rotator cuff (C).
In selected acute fractures and nonunions of the lateral clavicle, locked distal radius plate fixation provided excellent clinical results because it allowed earlier shoulder movements without necessitating implant removal. In our opinion, this may be the greatest advantage of using hook plates in treating unstable lateral clavicle fractures.

In our study, complications of K-wire fixation included K-wire migration, wire breakage, and loss of reduction. Meanwhile, complications of clavicular hook plate fixation included plate malposition, periprosthetic fractures, and pulling out of the plate. The malposition happened in the beginning of our series and is a technical fault that can be reduced with care and experience. Before the plate is removed, the hook can erode the acromion, and even a low-energy injury can break the clavicle medial to the plate. In our series, periprosthetic fractures occurred after repeated patient falls.

One other major concern of using a hook plate is subacromial migration and rotator cuff impingement. A study of 28 magnetic resonance imaging and ultrasonography shoulder images after hook plate fixation found neither high-grade rotator cuff impingement nor lesions. In a retrospective study of 34 patients operated on with hook plates, 1 had a rotator cuff tear induced by hook impingement. The authors concluded that rotator cuff tears are relatively rare; however, it is important to prevent subacromial impingement in the subacromial space. Our good clinical results also support that the hook does not irritate the rotator cuff. We recommend early implant removal to prevent such complications. The average hook plate implant removal time in our study was 5 months. No significant hook plate migration, rotator cuff injury, or osteoarthritis were noted in these patients.

Subacromial hook migration is also an issue requiring attention. Bending was required in 62 patients to fit the curve of the distal clavicle and acromioclavicular joint. In a retrospective study of 15 consecutive

Although transacromial K-wire fixation is a common fixation method, it has produced inconsistent results. For example, 1 study reported bony union and good results in all 32 patients treated with transacromial Knowles pins. Other studies also had good results using K-wire fixation. However, 1 study reported both a 47% complication rate and 32% nonunion rate in patients undergoing K-wire fixation. A more recent study compared K-wire fixation and clavicular hook plates and showed no differences in shoulder function and union rate; however, complication rates were higher in the K-wire fixation group. In comparison, the K-wire tension band wiring fixation group in our study achieved a good union rate but had a significant complication rate. Several studies reported common K-wire fixation complications such as loss of reduction and wire breakage. It is believed that K-wire fixation without threads can lead to serious complications, such as pin migration to vital organs. One report of a 26-year-old man with chest pain evaluated 2 years postoperatively showed K-wire migration outside the clavicle across the sternum to the opposite hemithorax.

One study of Wolter hook plate treatment reported good results in a small number of patients. However, the study showed a high rate of complications because as the hook hole in the acromion eventually enlarged, causing subsequent pain and shoulder motion limitation. Therefore, to avoid these complications, the AO hook plate was designed without an acromial hole. The hook plate provides resistance to the extracting forces of the shoulder muscles. In addition, as the acromioclavicular joint remains intact with no injury, no rotation movement limitation occurs during shoulder joint abduction and flexion. In a comparison of the mechanical strengths between K-wires with tension bands and clavicular hook plates, hook plates provided more stability than K-wires. When a hook plate is used, bone-to-bone tension can occur at the fracture site. More stable fixation allows an ability to start immediate postoperative range of motion exercises. Likewise,
patients with unstable lateral clavicle fractures treated with clavicle hook plates, 10 patients required plate bending. Forced fixation of a plate without a proper clavicle curve may result in migration or pulling out of the hook. Further improvement of the plate curve to fit the clavicle anatomy is necessary. In our study, the decision whether to bend plates or not was not related to a better shoulder Constant-Murley score.

Our study has several limitations. First, it was a retrospective study with no randomized design. Because surgeries were performed by 6 different surgeons, inconsistencies existed in surgical details and experiences. However, this is the largest study series thus far comparing K-wire fixation and clavicular hook plates in treating unstable lateral clavicular fractures. Our study showed that the groups were similar in both mean age and sex distribution while achieving good clinical results. Hook plate fixation may promote earlier bone union and statistically higher shoulder Constant-Murley scores with earlier implant removal. Although Constant-Murley scores were significantly higher in patients who underwent hook plate vs K-wire fixation, the clinical significance of the between group difference (at least in the short term) may be minimal. Continued follow-up is warranted to evaluate the long-term clinical outcome.

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