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COMPLICATIONS OF CIRCULAR PLATE FIXATION FOR FOUR-CORNER ARTHRODESIS

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Four corner arthrodesis is an accepted salvage operation for scapholunate advanced collapse and scaphoid non-union advanced collapse. Circular plates were introduced in 1999 and promoted as a rapid and more stable method for this procedure. A retrospective chart review was performed on all patients who were treated with the Spider Limited Wrist Fusion Plate (Kinetikos Medical Inc., San Diego, CA). Sixteen patients were identified and followed clinically and with X-rays for an average of 16 (range 5–38) months. Nine out of the 16 patients (56%) had complications, including non-union (25%), delayed union (6%), dorsal impingement (25%), radial styloid impingement (6%) and broken screws (13%). The purpose of this study was to compare our complication rate using circular plates with published outcomes using traditional methods of fixation: this study identified a significantly higher complication rate and lower union rate using circular plate fixation for four-corner arthrodesis compared with previously published techniques.

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Capito-lunate-triquetral-hamate, or ''four corner'', arthrodesis is an accepted salvage operation for scapholunate advanced collapse (SLAC) and scaphoid non-union advanced collapse (SNAC) (Krakauer et al., 1994; Watson and Ballet, 1984; Watson et al., 1981). Several techniques of performing this procedure are available, including screws (Ashmead et al., 1994), staples (Wyrick et al., 1995) and K-wire fixation (Calandruccio et al., 2000; Cohen and Kozin, 2001; Kirschenbaum et al., 1993; Sauerbier et al., 2000; Watson and Ballet, 1984). Circular plates were introduced in 1999 and promoted as a rapid and more stable method for four-corner arthrodesis. We have noted an increased frequency of complications with circular plate fixation in our unit and several recent studies have reported a high number of non-unions using the dorsal circular plate for this procedure (Kendall et al., 2005; Vance et al., 2005).

The purpose of this study was to identify the complication rate of using a dorsal circular plate compared to published outcomes using traditional methods of fixation for four-corner arthrodesis.

PATIENTS AND METHODS

After approval from our Institutional Review Board, a retrospective chart review was performed on all patients who had been treated with a single circular plate device (Spider Limited Fusion Plate; Kinetikos Medical Inc., San Diego, CA) for degenerative arthritis due to SLAC or SNAC.

Sixteen wrists in 15 patients were identified from the practices of two surgeons between 2001 and 2003. One patient had bilateral procedures for bilateral SNAC. The study cohort consisted of 13 men and two women with a mean age of 50 (range 29–76) years. Seven of the unilateral procedures were performed on the non-dominant wrist and eight on the dominant wrist. There were 11 SLAC wrists and five SNAC wrists. Average follow-up was 16 (range 5–38) months. In each patient, the scaphoid was excised and capito-lunate-hamate-triquetral arthrodesis performed. As instructed by the manufacturer, the Spider rasp was used over the four-corner junction until it was at least flush with, or below, the dorsal aspect of the carpus (www.visitkmi.com). The manufacturers recommend using a small rongeur to denude the cartilage between the four bones and then using autogenous cancellous bone graft. In our study, distal radius bone graft was used for all fusions and taken at Lister's tubercle. In addition, if the scaphoid had healthy cancellous bone, this was also used. The eight-hole spider plate was then aligned and every effort was made to follow the recommendations of the manufacturer, which states that, in general, two screws can be placed within each of the four bones (www.visitkmi.com). Every attempt was also made to restore the lunate to a neutral posture intraoperatively and to reduce the capitate in the coronal plane to seat directly into the concave surface of the lunate. Cast immobilisation averaged 3 (range 2–4) weeks and was followed by use of an orthoplast splint until union. (According to the manufacturer, a removable splint can be introduced at around 1 week to allow early active range of motion exercises or, alternatively, a short-arm cast can be used for 3 to 4 weeks for greater protection.) We tried to assess bony union radiographically by visualising bridging trabeculae in the fusion mass, for which three plain X-ray views were taken. However, time to union was difficult to diagnose on plain X-rays alone because the circular plate obscured the area of fusion (Fig 1).

Fig 1 Anteroposterior radiograph of the wrist demonstrating how the circular plate obscures the arthrodesis site and impairs the ability to assess union radiologically.

Therefore, we also evaluated fusion clinically by lack of tenderness at the fusion site. If union was in doubt on clinical examination, a CT scan was performed.

Patients were followed clinically and with plain X-rays for an average of 16 (range 5–38) months. Complications, including non-union, hardware failure and dorsal impingement, were identified by chart and radiographic review. Because of the limitations imposed by plain radiography and CT scans, we only included non-unions that were confirmed by revision surgery. Dorsal impingement was identified by a history of sharp dorsal wrist pain with maximal active, or passive, wrist extension and point tenderness elicited directly over the radiocarpal joint on clinical examination.

Complication rates were compared to a recent meta-analysis (Shin, 2001) using Fisher's exact test, with an α level of significance of 0.05.

RESULTS

A recent meta-analysis by Shin (2001) included 431 pts from eight series, utilising various methods other than dorsal plate fixation for four-corner arthrodesis. Complications rates were: non-union 2%, dorsal impingement 4.4% and an overall complication rate of 13.5% (95% confidence interval 10–17%). In our series, complications using the Spider plate™ included a 25% non-union rate (P-value = 0.0007), 25% dorsal impingement (P-value = 0.006) and an overall complication rate of 56% (95% confidence interval 30-80%; P-value = 0.0001).

One patient in our series failed to demonstrate radiographic consolidation of the fusion mass. While radiographic union was felt to be achieved initially in the other 15 cases, three patients subsequently developed pain, dorsal impingement or broken implants and were confirmed to have non-unions at the time of revision surgery. Thus, we report four non-unions (25%), confirmed by revision surgery. Of the four patients with non-union, three healed with revision surgery and one required an additional operative procedure for radiocarpal arthrodesis with iliac bone graft. The revision surgery was further complicated by deep infection of the iliac graft site. In two additional patients, the circular plate broke (13%) (Fig 2) but was only minimally symptomatic. In one of these patients, CT demonstrated healing of the fusion mass. The other has not had a CT scan performed. Four additional patients (25%) had dorsal impingement and two of these required removal of the plate for relief of symptoms. One patient had radial styloid impingement, necessitating radial styloidectomy, with relief of symptoms.

DISCUSSION

Scaphoid excision and four-corner arthrodesis provides a durable alternative to complete wrist fusion for degenerative disease secondary to chronic scaphoid nonunion or ligament instability (Krakauer et al., 1994; Watson and Ballet, 1984; Watson et al., 1981).

Fig 2 Anteroposterior X-ray of the wrist demonstrating two broken screws.

In addition to the meta-analysis performed by Shin (2001), many studies have demonstrated the efficacy of four-corner arthrodesis using traditional methods. Ashmead et al. (1994) reported on the results of 100 cases of four-corner arthrodesis for SLAC using K-wires. Only three patients (3%) developed a non-union and 12% of patients had evidence of dorsal impingement. Krakauer et al. (1994) reported on the outcomes of six different reconstructive procedures for 23 cases of SLAC. Four-corner arthrodesis was performed using staples in three cases, multiple Herbert screws for 1 case and K-wires in 19 cases. Two patients (8.7%) required repeat bone grafting for painful non-union.

Use of a dorsal plate for fixation was promoted to be a rapid and attractive alternative to traditional fixation methods, which required supplemental cast immobilisation for healing. However, Kendall et al. (2005) recently reported their results using a dorsal circular plate for four-corner arthrodesis. They reviewed the first 18 procedures performed for radioscaphoid arthritis retrospectively and noted that radiographic union was achieved in only three wrists and two patients required revision surgery for non-unions. They concluded that a circular internal fixation plate produced a high number of non-unions compared to the published results using other fixation methods. Vance et al. (2005) also performed a retrospective study and compared the results of four-corner arthrodesis using a circular plate ($n = 27$) with traditional fusion techniques ($n = 31$). They also concluded that the circular plate was associated with a higher complication rate, including non-union, impingement and patient dissatisfaction, than traditional methods.

Dorsal impingement following four-corner arthrodesis has previously been ascribed to radio-lunate abutment, resulting from inadequate reduction of the DISI deformity (Ashmead et al., 1994). Dorsal impingement following circular plate fixation of midcarpal arthrodesis is most likely secondary to hardware impingement on the dorsal lip of the radius (Fig 3). One patient also developed radial styloid impingement but did not have evidence of shortening of the carpus and had full correction of the lunate tilt. At our institution, we now perform a radial styloidectomy for patients that have a pointed or beaked radial styloid at the time of the initial procedure.

There are several limitations of our study which merit discussion. First, this is a small retrospective series without a comparative cohort group using traditional methods of fixation. We used, instead, a recently published meta-analysis (Shin, 2001) as a historical control and feel that this should provide a reasonable control against which to compare any new technique. Secondly, different postoperative regimens were used for patients after plate stabilisation and after the previous fixation techniques, as the plate fixation technique was believed to be more rigid, allowing earlier mobilisation. This different rehabilitation regimen could be responsible for the differences in union rates demonstrated between the plate and traditional fixation groups. Third, all patients treated with this implant were included, which may include a ''learning curve''. However, there was no difference in rate of non-union early in our series and later. Fourth, the manufacturer recommends reaming deeply to avoid dorsal prominence of the plate. In all the cases in this series, the dorsal intercalated segment instability (DISI) deformity was reduced and a conscious attempt was made to ream deeply and ''inset'' the plate within the carpal bones. However, it is still possible that even deeper reaming would be required to do this to a degree that would prevent dorsal impingement. Finally, although every attempt was made to follow the manufacturers guidelines, there were some cases in which this was not possible. For example, the manufacturer recommends that two screws should be placed within each of the four bones if possible. There were several cases where the osseous anatomy did not allow for the placement of two screws in each of the bones. In the four non-unions confirmed at revision surgery, all had two screws placed in the capitate and lunate. However, one patient had only one screw placed in the triquetrum.

Fig 3 Lateral X-ray of the wrist demonstrating how the circular plate contacts the dorsal lip of the radius during extension.

This study is by no means intended to be the definitive study of plate fixation for four-corner limited arthrodesis of the wrist. However, taken together with the study by Kendall et al. (2005) and Vance et al. (2005), our findings raise concern about this technique and should prompt further mechanical and clinical study of these implants before widespread clinical use.

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