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Prosthetic Arthroplasty of Proximal Pole Scaphoid Nonunions

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INTRODUCTION

Pseudarthrosis and necrosis of the proximal pole of the scaphoid are difficult to treat and the outcome is uncertain, particularly in elderly people. Eventually, this problem leads to radioscaphoid arthritis, which progressively spreads to the entire wrist and causes carpal collapse, in a typical pattern: scaphoid nonunion advanced collapse (wrist). In the same way, scapholunate dislocation rapidly leads to styloscaphoid arthritis in which the capitate collapses into the scapholunate space: scapholunate advanced collapse (wrist). Several authors have previously advocated the replacement of the proximal pole of the scaphoid. The silicon spacer promoted by Michon (1) then by Zemel (2) is no longer used and has been replaced by autologous biological materials proposed by Eaton (3). Jones (4) proposed a spherical vitallium implant, whereby the prosthesis was put into a cage with the risk of dislocation.

A novel implant which adapts to the kinematics of the carpus has recently been proposed (5). The adaptive proximal scaphoid implant (APSI; Bioprofile, Grenoble, France) is made of pyrolitic carbon. The total biocompatibility of this material has been previously proven (6,7). Hard wearing and chemically inert, it does not wear away the bone. Its friction coefficient is low when rubbing against bone and cartilage and allows it to slide between the cartilage and the surrounding ligaments to find the position of least resistance against the deformable walls of its biologic cage. Because it does not adhere to the surrounding walls, it does not apply pressure to the surrounding bones and does not initiate a dislocation.

Its module of elasticity is almost identical to that of bone, allowing it to be tolerated fully (Young's module: bone=20, APSI=25). This absence of difference between the elasticity modules avoids wear and tear on the bone.

This implant is distinctive in that its ovoid shape allows its "adaptive" mobility when the first row of carpal bones moves (6).

Frontally, the small radius corresponds to the scaphoid area of the radius, and from the side view the large radius forms an ovoid, of which the large curve is anteroposterior and the small curve is frontal (Fig. 1). By rotating on these axes during frontal deviation and flexion–extension movements, the APSI copies the movements of the proximal scaphoid exactly and becomes integrated in a corroborating and synchronous way with the kinematics of the carpal bones. Because of this three-dimensional reorientation during the movements of the wrist, the implant remains stable in the physiological amplitudes and does not require any form of fixation to the distal scaphoid or periprosthetic encapsulation (Fig. 2).

In view of the quality of the reported results with an open procedure, we decided to try placing the implant by arthroscopy. This report details our experience positioning this implant by using wrist arthroscopy.

INDICATIONS

This technique is only reserved for replacement of the proximal pole of the scaphoid in which reconstruction is not possible (excessively small fragment, an osseous fragment separated into several small pieces). The surrounding cartilage surfaces are generally intact without arthrosis. The use of this implant is a very good salvage procedure in elderly people but could be a "waiting" therapeutic option in young patients.

The contraindications include too large of a proximal fragment of the scaphoid (waist fracture) and significant chondral changes of the surrounding bones. The presence of styloid arthritis is not a contraindication because one can perform a radial styloidectomy during the same operative procedure. Furthermore, the minimally invasive technique is better than open surgery, because with the use of wrist arthroscopy the surgeon avoids a large approach and the normal risk of internal joint fibrosis.

CONSIDERATIONS FOR PREOPERATIVE PLANNING

Preoperative Physical Examination

The examination is the same as for all scaphoid nonunions: the surgeon should document the location of pain, range of motion, strength, and functional status. The examination is done comparatively to the opposite side.

Preoperative Imaging

Simple radiographies (frontal, lateral, and specific scaphoid view) are most often sufficient. Comparative X rays of opposite side are required. CT scan and MRI can be added in order to check the viability of the proximal fragments and the importance of chondral changes. Because the wrist continues to challenge clinicians with its array of potential diagnoses and treatments and multiple cartilaginous surfaces, combined with the intrinsic and extrinsic ligaments, wrist arthroscopy has proven to be a useful adjunct in the diagnosis and planning of scaphoid nonunions, and is a real part of the treatment.

SURGICAL TECHNIQUE

All patients in our series were operated on as outpatients under local–regional anesthesia using a pneumatic tourniquet (8). The arm is laid flat on an arm table, and axial traction is applied to the forearm and wrist using a wrist tower. The strength of

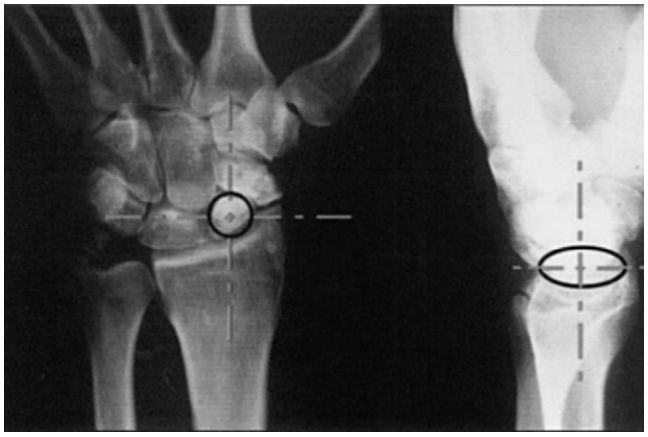


FIGURE 1 Position of the APSI in front and side view X-rays. *Abbreviation*: APSI, adaptive proximal scaphoid implant.

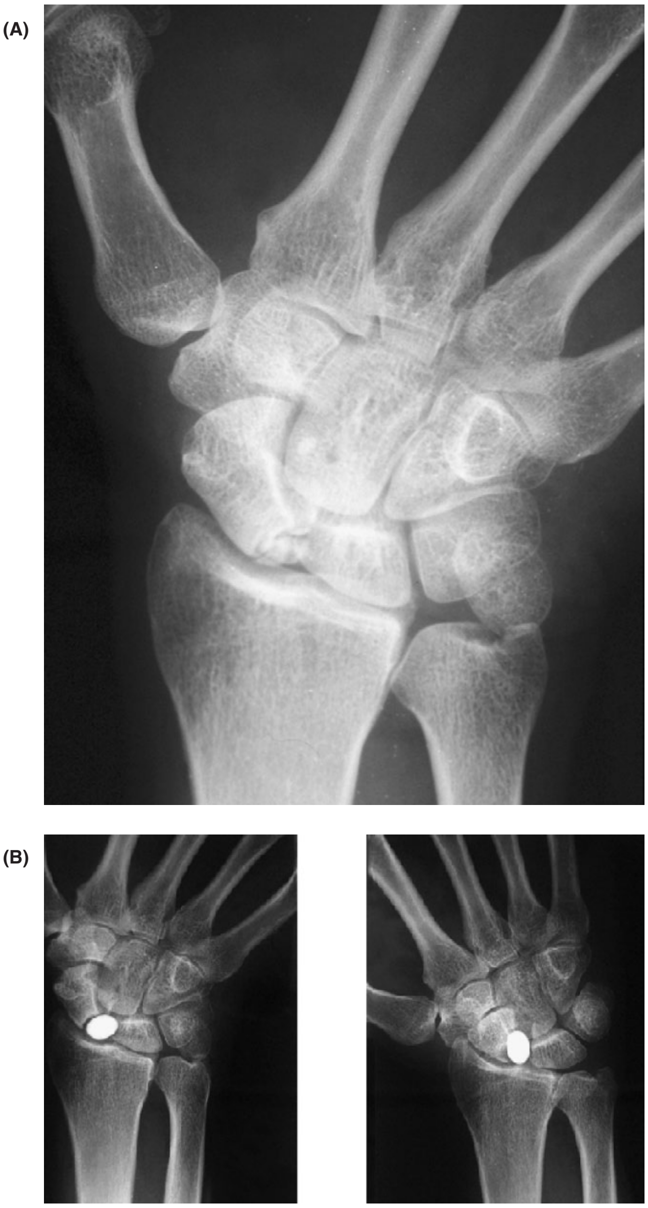


FIGURE 2 (**A**) X-ray of a case with untreatable necrotic proximal pole. (**B**) X-ray in ulnar and radial deviation showing the mobility and three-dimensional adaptability of the implant.

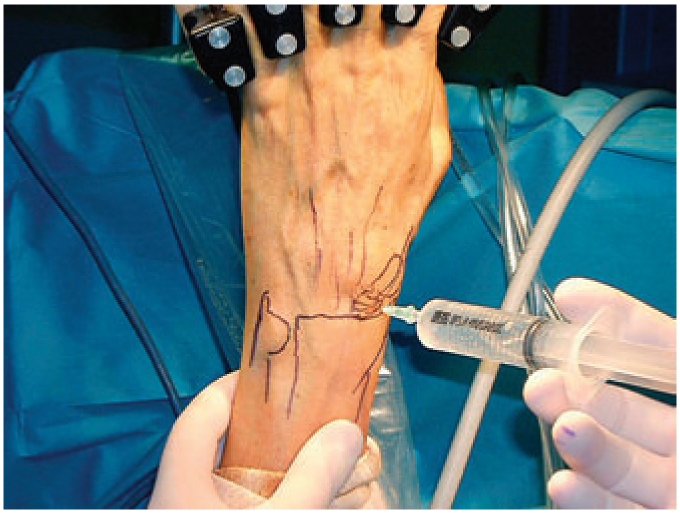


FIGURE 3 Radiocarpal joint filling.

the traction is usually 5 to 7 kgf. After drawing the different bone parts on the carpus, the wrist is filled with saline solution (Fig. 3).

At first, the arthroscopic guide and the arthroscope are positioned in the radiocarpal joint using 4–5 or 6-R radiocarpal portal. Exploration of the joint is performed, locating any possible associated lesions. After locating the proximal pole, a 3–4 radiocarpal portal is performed. This surgical approach is slightly larger than usual, about 1.5 cm, so that the proximal pole can be withdrawn and the implant put in place. The arthroscope can easily be positioned in this surgical approach, allowing direct access to the area of nonunion. A radial midcarpal surgical approach is used to analyze cartilage and to monitor the positioning of the implant.

After examining the proximal pole, the remaining cartilage is analyzed. First, the luno–radial area is analyzed in order to check that the cartilage between the lunate and radius is sound (Fig. 4A,B). Second, the quality of the cartilage between the distal scaphoid and the capitate is evaluated. It is often surprising to see good articular cartilage at this interval, especially in elderly people whereas considering the age of the lesions one would expect to see much more extensive cartilage degeneration. Finally, the state of the cartilage between the head of the capitate and the distal face of the lunate is analyzed.

Resection of the Proximal Part of the Scaphoid

Proximal pole resection is a relatively easy procedure, depending on how old the lesion is. In certain cases, it is necessary to use a burr to resect the proximal pole (Fig. 5). Sometimes we are faced with a small, necrosed proximal pole, weakly attached to the lunate by a few ligament fibers. The attachments are divided under arthroscopic control using instruments such as a surgical blade and small scissors (Figs. 6 and 7A,B). The detached proximal pole is easily withdrawn with forceps (Fig. 8). A radial styloid osteotomy is sometimes recommended to remove a painful contact between the styloid and the remaining distal part of the scaphoid.

Placing the Implant

First, the test implant is tried. There are three sizes:

- Small: length 16 mm and width 8 mm.

(A)

(B)

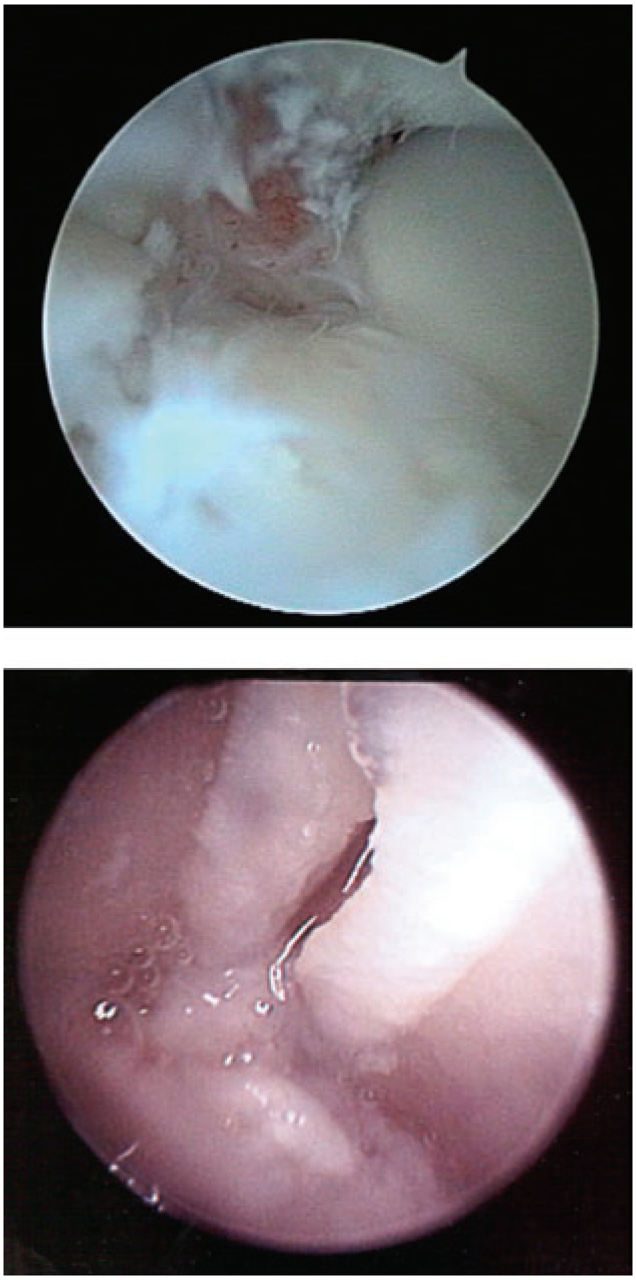


FIGURE 4 (**A**) Arthroscopic midcarpal view showing arthritis the position of necrotic proximal pole between the distal scaphoid on the left and the lunate on the right. (**B**) Arthoscopic view showing the chondral change of the capitate. The cartilage between the lateral side of the capitate and the medial side of the distal scaphoid is sound.

- Medium: length 17 mm and width 9.1 mm.
- Large: length 18 mm and width 10 mm.

The size is chosen on the operating table by positioning the test implants next to the resected proximal pole (Fig. 9). The test implant is then put into the radiocarpal joint in place of the proximal pole, and it is very satisfying to see how well this implant fits itself into the correct position (Fig. 10). After checking the correct congruence of the test implant by arthroscopy (Fig. 11A,B), it must be taken out. This is not always easy and is evidence of the good natural stability of the implant. It is replaced very easily by the definitive prosthesis, still under

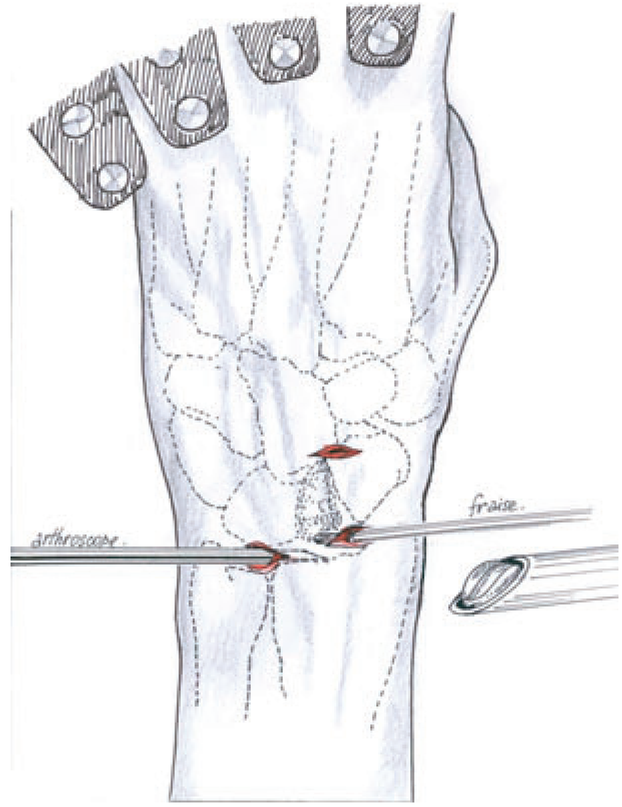


FIGURE 5 Diagram showing the 4–5 radiocarpal portal for the arthroscope and the possibility of proximal pole resection through the 3–4 radiocarpal portal using a burr.

arthroscopic control (Fig. 12). After removing the arthroscope, forced wrist movements are carried out to confirm that there is no dislocation of the implant. A representative case with pre- and postoperative X-rays is seen in Figure 13.

Postoperative Care

Only the 3–4 radiocarpal portal is closed by one or two stitches. As for normal wrist arthroscopy, it is not necessary to close the

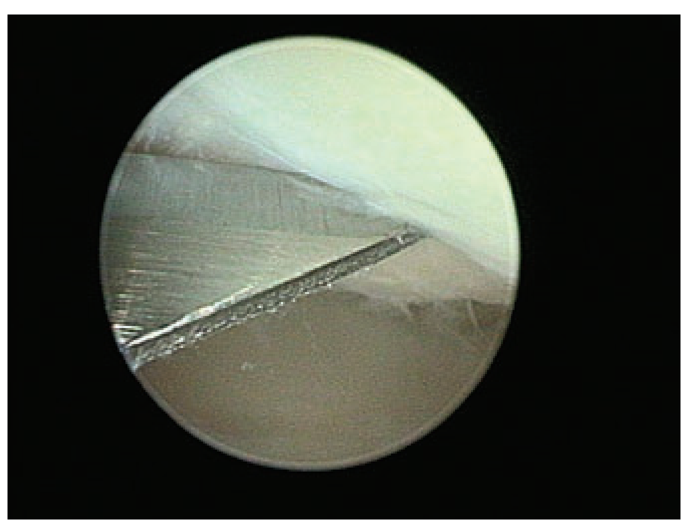


FIGURE 6 Radiocarpal arthroscopic view showing the use of a surgical blade to perforate the sacpholunate ligament.

(A)

(B)

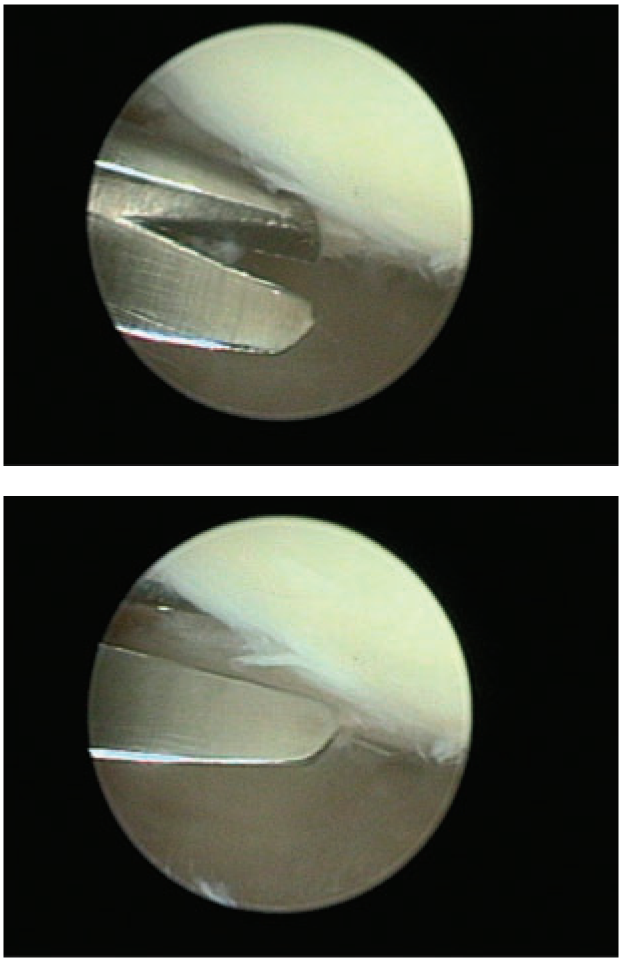


FIGURE 7 (**A**,**B**) Radiocarpal arthroscopic view showing the use of a scissors to separate the proximal pole and the lunate.

other portals. A protective dressing is put in place for eight days. Mobility is started immediately, letting the patient choose, themselves, the movements he or she wishes to make depending on postoperative pain. If necessary, rehabilitation can start after the third week.

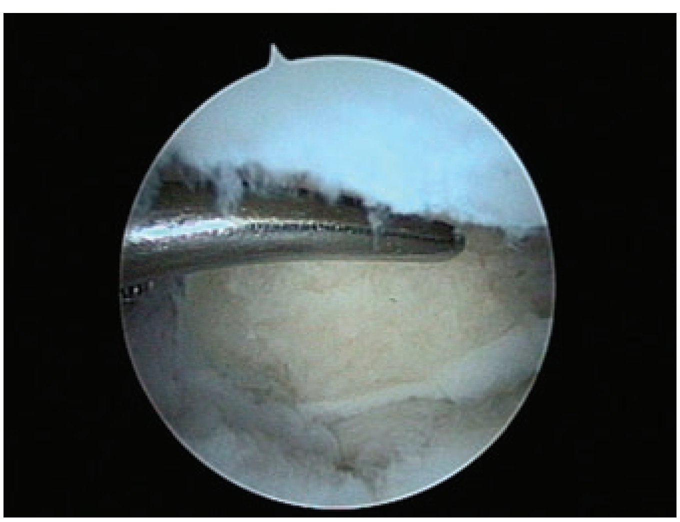


FIGURE 8 Radiocarpal arthroscopic view showing the proximal pole removal.

FIGURE 9 The resected proximal part of the scaphoid compared to the test and actual implants in order to choose the right size.

COMPLICATIONS

The most important technical point is to remove all fragments of proximal pole of the scaphoid. It is necessary to separate completely the scapholunate ligament attachment in order to easily remove the several pieces of bone, especially when they

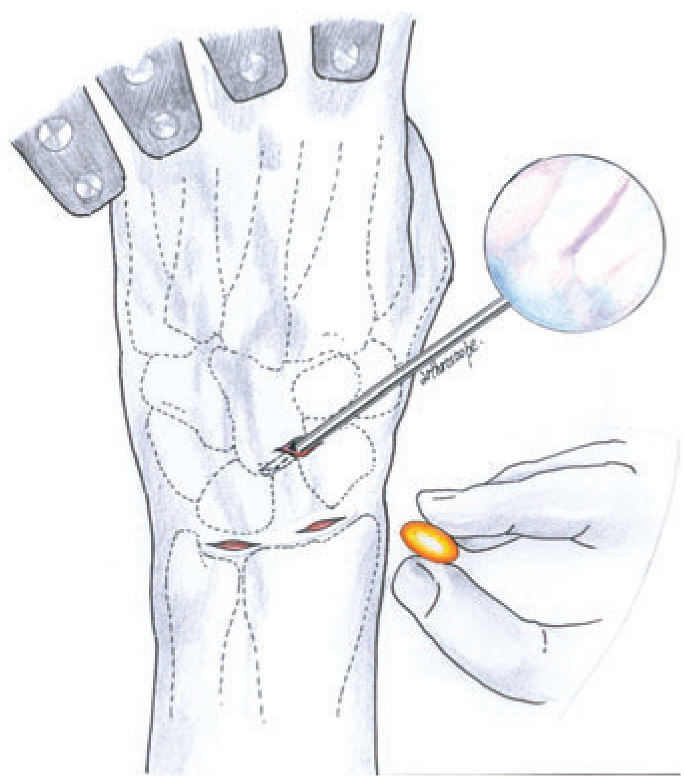
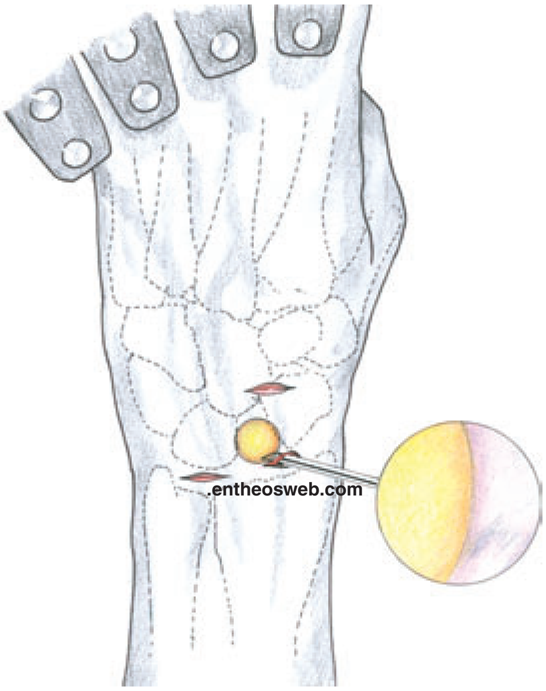


FIGURE 10 Diagram showing a radial midcarpal portal for the arthroscope before placing the test implant.

(A)



(B)

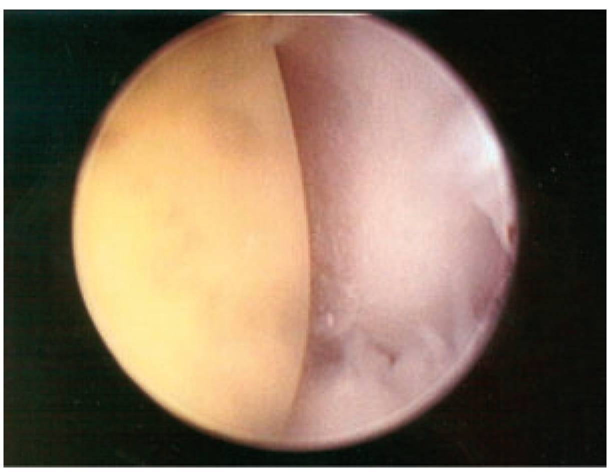


FIGURE 11 (**A**) Diagram showing a 3–4 radiocarpal portal for the arthroscope to check the correct position of the test implant. (**B**) Radiocarpal arthroscopic view showing the correct position of the test implant and the distal part of the distal scaphoid.

are small. Nevertheless, we have to take care not to damage the volar capsule to avoid volar dislocation of the implant in normal dorsal extension.

We had a case of volar dislocation of the implant postoperatively. It appeared that we created a little hole with scissors when we separated the attached proximal pole to the lunate. The implant passed by this hole and stayed in volar soft tissue. We had to replace the implant by a classic open volar approach and close the volar capsule perforation but had no further problems.

OUTCOME

We have operated on 18 patients during the period from the year 2000 to 2004. All were operated on as outpatients under

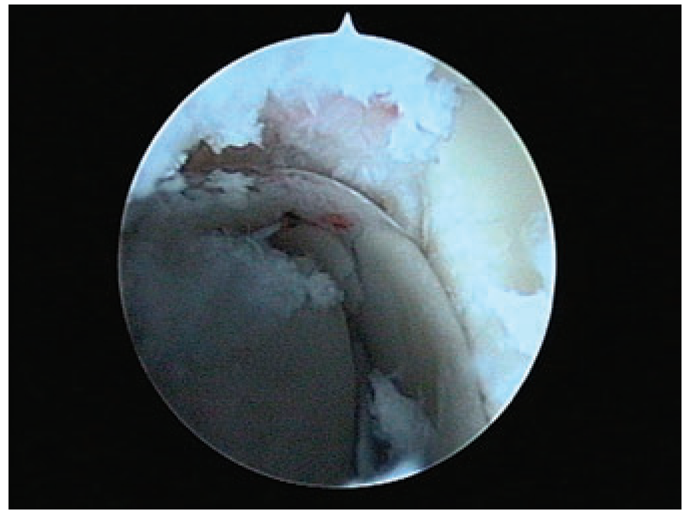


FIGURE 12 Midcarpal arthroscopic view showing the correct position of the implant. It is interesting to compare this view to the preoperative one (Fig. 4A) in order to see how the implant fits itself in the right position.

local–regional anesthesia using a pneumatic tourniquet. The average age was 49 years (range 40–81 years). There were 14 men and 4 women. All 18 patients were available for follow-up examination and radiographs.

The average follow-up time was 28 months (range 12–63 months). In younger people, we needed to place a volar splint in half of the cases. There were no immediate postoperative complications. We had one case of volar implant dislocation in the youngest patient, surely in connection with a lesion of volar capsule at the time of proximal pole removal. After intra-articular replacement, suture of the capsule, and cast immobilization for six weeks, the patient finally had a very good result.

We can separate these patients into two separate subgroups. The first series consisted of only elderly people: six patients. The average age was 76 years (range 72–81 years). All presented extensive arthritis with complete necrosis of proximal pole of the scaphoid and disabling pain. None of our six elderly patients had postoperative immobilization. The average follow-up was 39 months (range 25–63 months). The range of motion increased in all the cases from an average of 45° to 75° of active flexion–extension. None of these patients had pain at the longest follow-up. We did not have any complications.

The second series consisted of the youngest patients, 10 men and two women. The average age was 44 years (range 40–61 years). They all had necrotic proximal poles of the scaphoid in which the reconstruction and/or revascularization was impossible due to the small necrotic pieces of scaphoid. All had no adjacent chondral changes except in front of the proximal pole. The average follow-up was 23 months (range 12–49 months).

The major complication in this series was the one case of volar implant dislocation. We had two failures in poor indications (nonunion of the waist scaphoid). This technique should be reserved only for the proximal pole nonunions because the size of the implant is not adapted for replacement of a large part of the scaphoid. We performed palliative treatment in these cases (one four-bone arthrodesis and one proximal row carpectomy).

Except these two cases, all the other cases had excellent to good result without significant pain based on a modified Mayo Wrist scoring system and were completely satisfied. Pain disappeared completely after three months. In all the cases,

FIGURE 13 (**A**,**B**) Case 1: Front and side view X-rays of a necrotic proximal pole of the scaphoid. (**C**,**D**) Case 1: Side and front view X-rays showing the perfect position of the implant postoperatively.

the wrist range of motion improved in the flexion–extension arc from an average of 50° before surgery to an average of 100° after surgery. The incisions all healed well with very minimal scarring (Fig. 14). The parameters of radial–ulnar deviation and grip strength improved markedly after surgery.

FIGURE 14 Cosmetic appearance without scar.

SUMMARY

The indications are rare and reserved only for necrotic proximal pole, but when the rules of placement are respected, arthroscopic arthroplasty for proximal pole scaphoid nonunion is a safe and reliable procedure. It is a simple salvage procedure in elderly people but could be a "waiting" therapeutic option in young patients with necrotic proximal pole of the scaphoid.

Brief Indications

Replacement of necrotic, unreconstructable proximal pole of the scaphoid.

Outcomes

- Good increase in range of motion.
- Excellent reduction in pain.

Complications

- One case of volar implant dislocations.
- Two failures in bad indications (nonunion of the waist scaphoid). These cases required palliative treatment (one four-bone arthrodesis and one proximal row carpectomy).

REFERENCES

1. Michon J, Merle M, Girod J, et al. Replacement prothetique des os du carpe. In poignet et medicine de reeducation. Paris: Masson, 1981:255–63.
2. Zemel NP, Stark HH, Ashworth CR, et al. Treatment of selected patients with ununited fracture of the proximal part of the scaphoid by excision of the fragment and insertion of a curved silicone rubber spacer. J Bone Joint Surg 1984; 66:510–7.
3. Eaton RG, Akelman E, Eaton BH. Fascial implant arthroplasty for treatment of radioscaphoid degenerative disease. J Hand Surg 1989; 14:766–74.
4. Jones JK. Replacement of the proximal portion of the scaphoid withspherical implant for post-traumatic carporadial arthiritis. J Hand Surg 1985; 10:217–26.
5. Pequignot JP, Lussiez B, Allieu Y. Implant adaptatif du scaphoide proximal. Chirurge De La Main 2000; 2:276–85.
6. Chen L, Vincent J, Hetherington L, et al. A review of pyrolitic carbon: application in bone and joint surgery. J Foot Ankle Surg 1993; 32:490–8.
7. Cook SD, Beckenbaugh R, Weinstein AM, et al. Pyrolitic carbon implants in the metacarophalangeal joints of baboons. Orthopedics 1983; 6:952–61.
8. Mathoulin CL. Arthroscopic arthroplasty for proximal pole of scaphoid nonunion. In: Geissler WB, ed. Atlas of Hand Clinics. Philadelphia, PA: W.b. Saunders Company, 2001:341–58.