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ORIGINAL ARTICLE

Vascularised bone graft with mini-acutrak® fixation in scaphoid pseudoarthrosis with proximal pole necrosis

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KEYWORDS
Scaphoid nonunion;
Necrosis proximal pole scaphoid;
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Abstract
Objectives: We studied the use of vascularized bone graft (VBG) in combination with a fixation with screw in patients with scaphoid nonunion and avascular proximal poles.
Materials and methods: Between January 2006 and December 2009, we treated 10 patients with scaphoid nonunion with avascular proximal poles. There were 10 males with nonunion. Their average age was 27 years (range: 18-46 years). The average follow-up was 18 months (range: 12-43 months). The clinical valuation was the scale of pain (VAS), the range of motion and grip strength. The radiological valuation included radiographies, CT and MRI. We studied the scapholunate angle, the Carpal Height Index by Nattrass et al. and the Mayo Wrist Score.
Results: The mean preoperative VAS was 4.5 (2-8) and postoperative VAS 1 (0-2). All patients achieved union in an average time of 15 weeks (range: 6-25 weeks). X-rays and CT showed a complete osseous union in all patients. Carpal Height Index was a mean of 1.50 preoperative and 1.58 postoperative. The scapholunate angle was a mean of 52º preoperative and 49º postoperative. Mayo Wrist Score was 53 preoperative and 92 postoperative.
Conclusions: We have found that the technique which combines VBG with mini acutrak® screw, is successful in treating scaphoid nonunions with avascular poles. We prefer to use the vessel 1, 2 ICSRA. If this vessel is occasionally absent, other pedicles may be used.

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PALABRAS CLAVE
Pseudoartrosis de escafoides;
Necrosis polo proximal escafoides;
Injerto óseo vascularizado

Injerto óseo vascularizado y fijación con mini-acutrak® en las pseudoartrosis de escafoides con necrosis del polo proximal

Resumen
Objetivo: Evaluar los resultados del injerto óseo vascularizado (IOV) de la arteria 1, 2 suprarretinacular intercompartimental (1,2 SRIC) junto con la fijación, en pseudoartrosis de escafoides y necrosis del polo proximal.
Material y método: Realizamos un estudio retrospectivo, entre enero de 2006 y diciembre de 2009. Se trata de 10 pacientes con pseudoartrosis de escafoides con necrosis del polo proximal. Todos eran varones con edad media de 27 años (rango: 18-46). El seguimiento medio fue de 18 meses (rango: 12-43). La evaluación clínica incluye el dolor según la escala visual analógica (EVA), el balance articular y la fuerza de prensión. La evaluación radiológica incluye radiografías, TC y RNM. Se midió el ángulo escafolunar y la altura carpiana de acuerdo con el índice de Nattrass et al. La escala utilizada fue la Mayo Wrist Score.
Resultados: La consolidación tuvo lugar en todos en un tiempo medio de 15 semanas (rango: 6-25 semanas). La media de EVA preoperatoria fue de 4,5 (2-8) y postoperatoria de 1 (0-2). El índice de la altura carpiana de Nattrass preoperatorio fue de 1,50 y postoperatorio de 1,58. El ángulo escafolunar medio preoperatorio fue de 52º y postoperatorio de 49º. Los valores preoperatorios de la Mayo Wrist Score fueron de 53 y los valores postoperatorios de 92.
Conclusiones: La técnica que combina el IOV y la fijación con un tornillo mini-acutrak® presenta buenos resultados, en el tratamiento de las pseudoartrosis de escafoides con necrosis del polo proximal. Preferimos el uso de la arteria 1,2 SRIC. En el caso de que esta arteria esté ausente se pueden utilizar otros pedículos vasculares.

Introduction

Scaphoid nonunion is a surgical problem, especially when associated to proximal pole necrosis.[1] The incidence of nonunion is higher in this region due to lack of vascularisation of the proximal scaphoid segment.[2,3] This is why many techniques for nonunion treatment have been reported with good results in 70% - 90% of cases. However, when there is also a proximal pole necrosis, the results are not so good.[4] Filan y Herbert[5] observed that only a third of patients with scaphoid nonunion and proximal pole necrosis treated with an iliac crest graft and fixation with a Herbert screw achieved fracture union. The advantages of vascularised bone graft (VBG) compared to conventional bone grafts are: 1) greater speed in fracture union and 2) vascularisation enhancement and osteogenesis of avascular fragments.[6] The study aim was to assess VBG use described by Zaidemberg et al (1991),[7] when combined with an internal fixation as described by Carter et al (1989),[8] in patients with carpal scaphoid pseudarthrosis and proximal pole necrosis. We modified this technique using a cannulated mini-Acutrak® screw (Acumed, Hillsboro, OR).

Material and method

Between January 2006 and December 2009, we surgically operated on 10 patients who presented scaphoid pseudarthrosis with proximal pole necrosis (fig. 1). We used a VBG in the 1, 2 intercompartmental supraretinacular artery (1,2 ICSRA) (fig. 2). All patients were males, with a mean age of 27 years (18-46). The mean follow-up was 18 months (12-43). The period of time between the initial trauma and surgical procedure was 9 months (range: 3-24). The patients had initially been treated with a forearm cast for 6 weeks, except for 3 cases in which the fracture was not diagnosed and so did not receive orthopaedic treatment. All patients reported wrist pain that increased with daily activities, work or sport. A fall with the wrist extended was found in all cases. In two cases, the fall occurred in the street; in 4 cases, while playing sport; and in 4 cases, after motorcycle accidents. The dominant hand was affected in 9 patients. The preoperative clinical assessment included pain, range of wrist motion and grip strength. Pain assessment was carried out using a visual analogue scale (VAS) that went from 0 (no pain) to 10 (severe pain). At the end of the follow-up, the mobility range was assessed using a goniometer and grip strength using a dynamometer (Jamar, Sammons Preston, Abililtyone Company, Bolinbrook, IL). Wrist function was measured according to the Mayo Wrist Score. Radiological assessment included wrist projections: posteroanterior (PA) in neutral rotation, PA in ulnar and lateral deviation. Scaphoid pseudarthrosis with proximal pole necrosis was grouped according to the Filan and Herbert classification.[5] A magnetic resonance imaging scan (MRI) was carried out in all cases and reported proximal pole necrosis. A preoperative CT scan was available in 7 cases. Postsurgical scaphoid assessment included

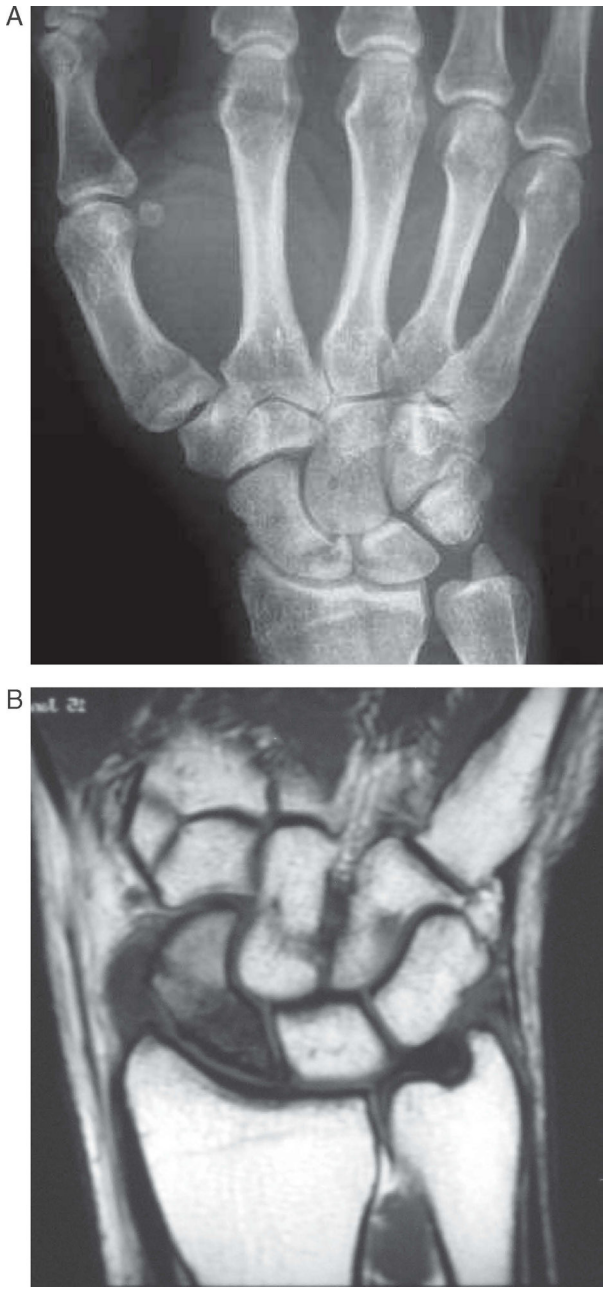

Figure 1 Scaphoid pseudarthrosis with proximal pole necrosis. A) PA radiological projection. B) Coronal MRI view and enhanced T1 image.

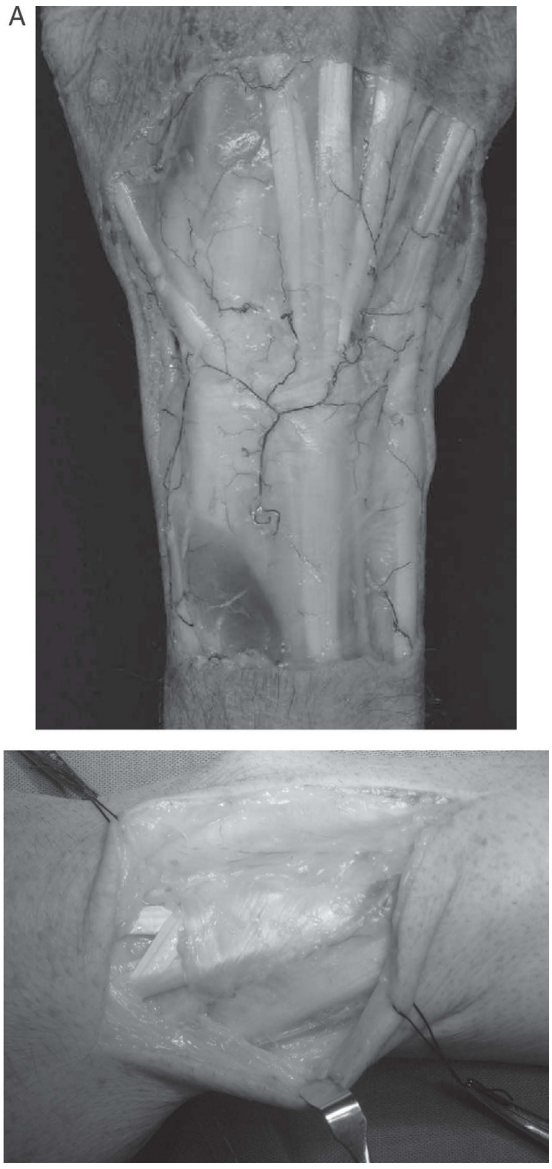

Figure 2 The 1, 2 ICSRA vessel located on the dorsal surface of the extensor retinaculum between the first and second compartments. A) Anatomic image with a black latex injection and Spalteholz technique. B) Clinical image.

consolidation, incorporation of the graft and scaphoid length restoration, assessed in PA and lateral x-rays obtained at 6 and 12 weeks, and at the end of the follow-up. Carpal Height Index was measured before and after surgery according to Nattrass et al (mean value 1.57±0.05).[9] The scapholunate angle was measured pre- and postoperatively. Fracture consolidation is diagnosed when there is radiographic bone trabeculae step in the previous nonunion area, with proximal and distal integration of the bone graft. A CT scan was carried out on all patients to confirm consolidation. A MRI was performed in 6 cases to assess bone graft viability, fracture healing and graft incorporation. Disease progression to osteoarthritis was assessed on the criteria basis proposed by Watson y Ryu.[10] In stage 1, there are degenerative changes between the radial styloid and the distal scaphoid; in stage 2, the changes extend proximally to the radio-scaphoid joint; and in stage 3, there are degenerative changes between the capitate bone and the scaphoid, and between the capitate bone and the lunate bone.

Surgical technique

The patient is placed in a supine position under axillary anaesthesia with a pneumatic cuff and limb expression. A longitudinal dorsal curvilinear incision is performed. The

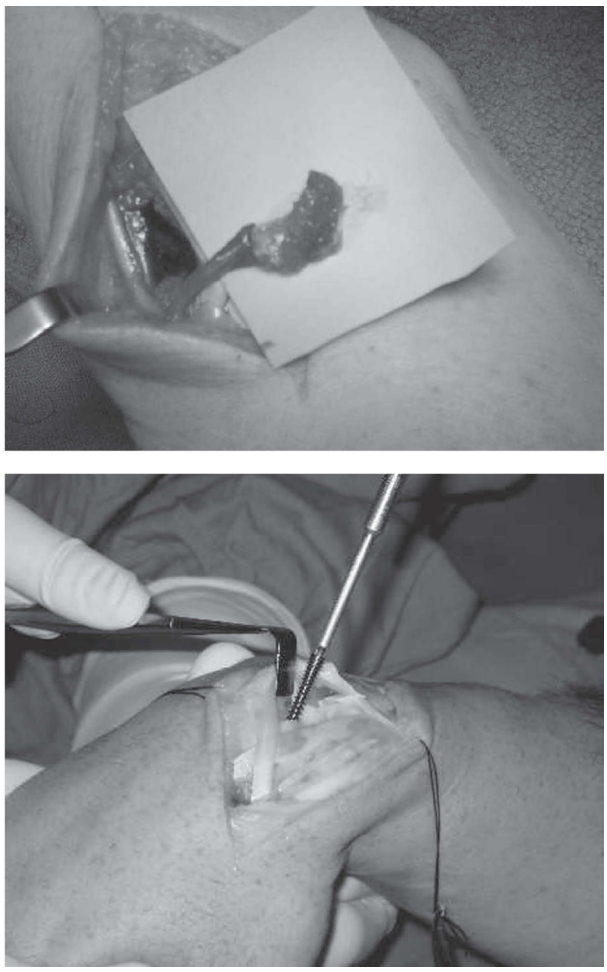

Figure 3 A) Vascularised bone graft. B) Cannulated mini-Acutrak screw fixation.

skin and subcutaneous tissue protecting the superficial branch of radial nerve are removed. Once the retinaculum is exposed, the supraretinacular artery is identified between the first and second extensor compartments or 1,2 ICSRA vessel, also called the first septal dorsal artery or that described by Zaidemberg et al,[7] ascending superficial to the extensor retinaculum. An incision in the extensor retinaculum at the level of Lister's tubercle is made by dividing the space between *Extensor Pollicis Longus* and *Extensor Digitorum Communis*. The incision in the dorsal capsule allows the scaphoid proximal pole, lunate and scapholunate ligament to be exposed. Once the proximal pole is exposed, a cannulated scaphoid mini-Acutrak® screw is placed using a hands-free technique. Scope control is performed, although we cannot see the wire guide throughout the entire length because the wrist must be bent to help to introduce the guide wire. The thumb axis is used as a guide to place the screw guide. The screw is positioned according to the technique described by Carter et al.[8] It is inserted as volar as possible without producing a cortical lesion. We normally use a 20 or 22mm mini-Acutrak® screw. The fluoroscopy is carried out once the screw has been inserted to check if it has been correctly positioned. Once the screw has been positioned, then a rectangular space is dug in the nonunion place. It is important not to expose the screw with this gesture. The proximal pole is inspected to assess that there are no bleeding points and that it is avascular. After a recipient is created in the scaphoid to insert the bone graft, the graft extraction is carried out. We make an incision in the periosteum, which includes the bone graft. The graft is raised with part of the retinaculum and its vascular pedicle 1,2 ICSRA artery. The artery should not dry out. The VBG is transferred to the fault created in the scaphoid without causing tension in the vascular pedicle (fig. 3). The graft is fixed, pressing only at the ends. We do not normally let go of the ischemia to see the graft flow. We consider that the vascular pedicle works if we have been careful in extracting it and if the vessel keeps the same size and colour as at the start of surgery. The bone graft should also have a good appearance with bleeding points during extraction. If the vascular pedicle acquires a transparent hue during surgery, we might think that it is a vasospasm and should free the ischemia to check the graft flow. The capsule, extensor retinaculum and skin are then closed. It should be immobilised with plaster for 6 weeks and rehabilitation should be started after that.

Results

The mean pre-operative VAS was 4.5 (2-8) and the postoperative mean was 1 (0-2). The flexion-extension range of motion was increased from a mean value of 110º before surgery (range: 93º-123º) to 115º (range: 82º-137º) after the operation. The increase in radio-ulnar deviation was from 40º (range: 39º-58º) before surgery to 51º (range: 34º-65º) after the operation. Preoperative grip strength was a mean value of 32kg and was increased to 48kg postoperative. At the end of the follow-up, all patients achieved fracture consolidation in a mean time of 15 weeks (range: 6-25 weeks). All patients could reinstate their everyday activities, although two out of ten reported discomfort when lifting heavy objects. The vascular pedicle 1,2 ICSRA vessel was used in the surgical procedure for all the cases. The postoperative x-rays and CT scan showed fracture consolidation in patients treated with this method (fig. 4). The preoperative Nattrass carpal height index was 1.50 and the postoperative was 1.58. The mean scapholunate preoperative angle was 52º; the postoperative, 49º. Mayo Wrist Score values were 53 preoperative and 92 postoperative. No degenerative changes, infection, reflex sympathetic dystrophy, persistent nonunion, sensory branch lesion of the radial nerve or morbidity graft donor site were reported.

Discussion

Patients with carpal scaphoid pseudarthrosis and proximal pole necrosis have not had good results using conventional bone graft techniques.[3,6,11] In 1983, Braun[12] described a distal radius bone graft based on a vascular pedicle of the anterior interosseous artery and pronator Quadratus muscle.

Figure 4 A) PA radiological projection. B) CT showing scaphoid consolidation after VBG in 1,2 ICSRA vessel.

This technique achieved fracture consolidation in 5 patients with scaphoid pseudarthrosis. Despite the popularity of this pedicle, there are different anatomical variants in the position and diameter of the vessels, the rotation range is short, and the carpal has to be exposed through the palmar, with potential carpal instability. The VBG based on palmar radiocarpal arch has also been used successfully in scaphoid nonunion and has a greater blood supply and rotation range.[13] However, some cases of lesion in the palmar radiocarpal ligaments have been reported on raising the graft due to their close proximity to the palmar radiocarpal arch.[3]

In 1991, Zaidemberg et al[7] described a VBG based on the first septal artery, or ascending artery of the radial styloid, the dorsal branch of the radial artery. Sheetz et al[14] described 4 arterial vessels at the back of the wrist, two superficial to the extensor retinaculum and two deep. The two superficial ones are located between the first and second and between the second and third extensor compartments. These two arteries are called 1,2 and 2,3 intercompartmental supra-retinacular arteries (ICSRA). The other two arteries at the back of the wrist are deep, located at the base of the 4 and 5 extensor compartment.[15,16] We preferred to use the vessel described by Zaidemberg et al[7] or 1, 2 ICSRA vessel. If this vessel is absent, something that occurs in 6% of cases according to Sheetz et al[14], we can use other vascular pedicles.[15]

Smith y Cooney[17] contributed with 100% consolidation with VBG in 3 patients with scaphoid nonunion where a conventional technique had failed. Chang et al[18] concluded that VBG based on a 1,2 ICSRA vessel is effective in scaphoid nonunion treatment and that treatment success depends on choosing the appropriate surgical technique. Some cases of persistent nonunion have been described using VBG.[18,19] However, all our study patients achieved fracture consolidation. Blood supply with VBG, together with screw fixation, provides a biological supply that favours consolidation with respect to conventional bone grafts.[4] For some authors,[6,20] VBG provides a quicker and stronger consolidation. At any rate, these studies are still limited to determining what the real blood supply level is in the lesion area.[6] A proximal avascular scaphoid fragment is associated with the development of osteoarthritis. Ruby et al[21] described the sequence of degenerative changes in 31 patients with scaphoid nonunion and noted that osteoarthritis developed, when there is proximal pole necrosis, about 4 years later. We did not report any osteoarthritis in any patients at the end of our study follow-up.

Pre-surgical assessment of proximal pole necrosis in scaphoid nonunion is carried out using radiological projections and an MRI. Cerezal et al[22] studied MRI with gadolinium for pre-surgical vascular assessment of the proximal fragment in scaphoid nonunion. They concluded that this test demonstrated a sensitivity of 66%, a specificity of 88% and an exactness of 83%, respectively. Thus, MRI images enhanced with gadolinium are the most reliable method to investigate vascularisation of the proximal pole with scaphoid nonunion.

The technique described, combining VBG with a cannulated mini-Acutrak® screw, is safe and allows fracture consolidation in scaphoid nonunion with proximal pole necrosis. In these cases, VBG of the first septal artery would be the treatment of choice.[23] We recommend this procedure in scaphoid nonunion with proximal pole necrosis without osteoarthritis.

Evidence level

Evidence level IV.

Conflict of interest

The authors declare no conflict of interest.

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