

OUR CLASSICS

Pseudoarthrosis of the carpal scaphoid. Therapeutic considerations

Seudartrosis del escafoides del carpo. Consideraciones terapéuticas

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Fractures of the scaphoid tend to occur more frequently than fractures of any other carpal bone with an incidence of 70% according to Uffreduzzi, 73% according to Tranquilli-Leali, and 67% according to Branciforti-Franz-Zappoli. In the majority of cases, the fracture line tends to be located in the intermediate region, with fractures of the tubercle and the proximal pole being far less common. According to Trojan, in fractures that occur in the intermediate region, the fracture line follows an oblique path in 50% of cases and a horizontal path in 47% of cases; vertical fractures are extremely rare (3% of cases).

Mechanical and biological factors combine to give rise to pseudoarthrosis. The longitudinal axis of the scaphoid greatly exceeds that of the lunate so that its distal end is in relation with the trapezium, the trapezoid and the capitate. Strong ligament connections are attached proximally to the first carpal row and distally to the second. As mentioned above, the majority of fractures occur in the middle third, causing an alteration in the fracture line between the two carpal rows, so that the new axis of movement runs through the fracture line approximately where the joint line extends between the lunate and the capitate, and the triquetrum and the hamate.

In flexion-extension of the wrist, the proximal portion remains attached to the lunate bone, whereas the distal part moves with the bones of the second carpal row. When the hand is adducted, the fracture line tends to widen, while when it is abducted it usually narrows. Insufficient immobilization that allows a certain degree of movement between the carpal bones will disrupt the normal fracture healing process.

Bernard and Stubbins (1948) and Smith-Friedman (1956) attached great importance to the mechanical action of the styloid process of the radius on the distal portion of the scaphoid. When the hand is abducted, the styloid process would cause continuous microtrauma to the said fragment.

Verdai (Judet) underscores the importance of the action carried out by the ligament that runs from the radial epiphysis to the hamate bone. In pronation movements, this ligament becomes taut, pressing the scaphoid and thereby mobilizing the fractured fragments.

Blood supply to the scaphoid has been studied by several authors (Schneck, 1930; Logroscino-De Marchi, 1938; Obletz-Helbstein, 1938; etc.). According to Logroscino, the feeder vessels penetrate the bone at the level of the tubercle or the middle portion. Obletz and Holstein studied the distribution of the nutrient foramina and found that in 67% of cases, these are located in the tubercle, in 20% of cases there is one single feeder hole in the middle region and in 13% of cases no vessel enters this region.

Watson Jones built on the work of these authors and found that in one-third of cases vascular penetration occurred only in the distal half of the bone. De Anquin described 3 vascular systems: periosteal arteries, which do not penetrate the cancellous tissue, capsular arteries, which irrigate a small portion of the underlying bone, and intraosseous arteries, i.e. the artery of the tubercle and that of the body of the scaphoid.

The distal scaphoid is invariably characterized by abundant blood supply. The middle portion generally receives sufficient blood supply, albeit somewhat irregularly. The proximal portion must always contend with unfavorable

nutrition conditions. Healing can only take place through slow and progressive vascular rehabilitation.

Conservative treatment of scaphoid fractures has been perfectly systematized and a consensus has been reached by the majority of authors, who agree that prolonged immobilization should be the mainstay of treatment (on the basis of the mechanical and biological premises mentioned above, which cause this bone to be especially prone to delayed healing and necrosis). The opposite is the case in the treatment of pseudoarthrosis, a problem most authors consider difficult to solve.

Numerous techniques have been suggested to carry out the said treatment.

Excision of the whole or of part of the scaphoid (Dwyer and Cave, Gurd, Hirsch, Dewey, Sashin, etc.) far from yielding good results has given rise to severe alterations in wrist function (Vernon Luck, Kemper) (Fig. 1). Nor have Beck-style multiple perforations achieved any consistent success (Soto Hall, Bunnel, Oblatz-Halbstein, etc.). Replacement of the scaphoid with an acrylic or vitallium prosthesis (Waugh, Pauling) has also been unsuccessful.

A significant step forward was made when perfect immobilization of both fragments was achieved by

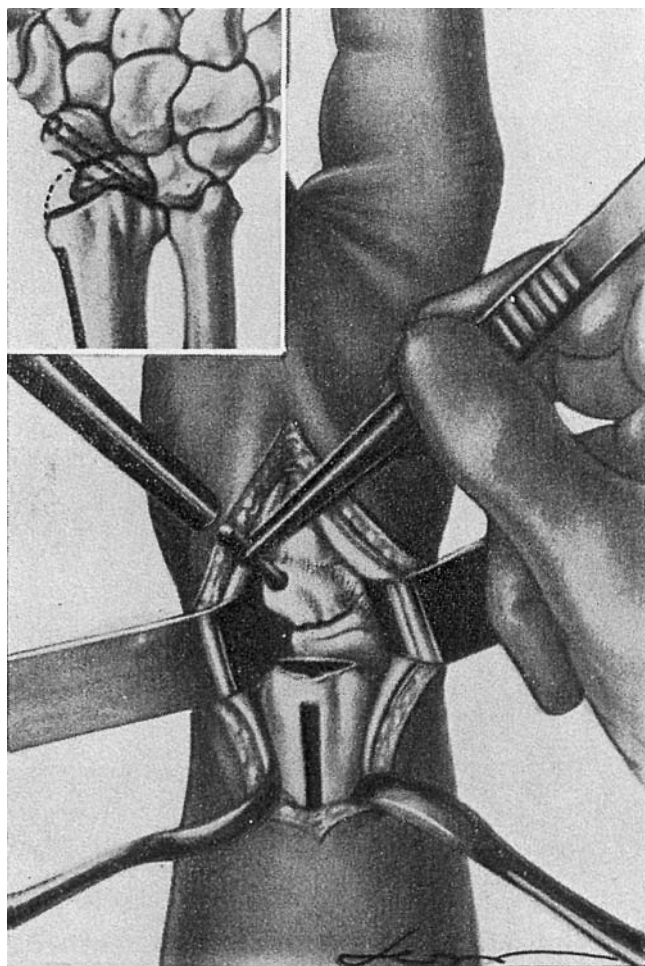


Figure 1 Illustration of the surgical procedure (from *Folia Orthop.*).

osteosynthesis with a cortical graft, which in addition stimulated osteogenesis.

Cortical grafting, originally used by Adams and Leonard (1928), was made popular by Murray (1946) (Fig. 2). This author carried out a posterolateral incision in order to skeletonize the external border of the scaphoid. He subsequently drove a tunnel, which started at the tuberosity and ran through both fragments. A cortical graft is introduced into the said tunnel, which immobilizes both fragments. This technique is used not only in cases of pseudoarthrosis, but also in fresh fractures with magnificent results (95% of cases healed successfully).

Matti (1936) suggests a direct approach to the site of pseudoarthrosis in order to refresh the fracture surfaces, filling the space created with cancellous iliac bone. Even if this technique does not achieve fragment consolidation, it does however yield good results (80% of fractures went on to heal).

Mercer uses a pedunculated graft harvested from the ipsilateral radial metaphysis, which he places on a bed created in the scaphoid.

Mc. Laughlin advocates the technique of osteosynthesis with a vitallium screw, applied even to fresh fractures with magnificent results (fig. 3). Although he does he manage to obtain radiological healing in any of the cases of pseudoarthrosis treated with this techniques, the functional results are good in all of them because he obtain perfect fragment immobilization. Passer (1960) expounds the advantages offered by screw osteosynthesis in scaphoid pseudoarthrosis, with good functional results in 18 of the 20 cases in which he used this technique.

Radial styloid resection (Bernard and Stubbins, Smith-Friedmann, 1956, etc.) has been proponed in order to avoid the microtrauma provoked by the radial styloid process on the distal scaphoid fragment. Although this technique has been applied in isolation, it is generally used in conjunction with some fixation method. Rusee modified Matti's technique by combining the cancellous graft with a cortical graft that reinforces immobilization. Lastly, Merle D'Aubigné (1958), suggests the use of screw osteosynthesis combined with a cortical graft (fig. 4).

Our observations comprise 15 cases of pseudoarthrosis treated surgically at the Rizzoli Orthopedic Institute. As far as age is concerned, 3 cases correspond to the second decade in life, 6 to the third; one to the fourth, 3 to the fifth, one to the sixth and one to the seventh.

All patients were male. The affected side was the right side in 8 cases and the left side in 7.

We analyzed the potential causes leading to pseudoarthrosis and observed that in 6 cases the fracture had initially gone undetected and was subsequently diagnosed as a result of the functional alterations it provokes in the later stages of pseudoarthrosis. Of these cases, one did not have any obvious traumatic precedent, with a contralateral radiological examination ruling out the possibility of a bipartite scaphoid. In one case treated as a fresh fracture 14 years before, the pseudoarthrosis had not since caused pain or functional limitations, allowing the patient to carry out his normal occupational activities. This patient suffered slight wrist trauma on putting down a load, which triggered a series of alterations that made the diagnosis possible.

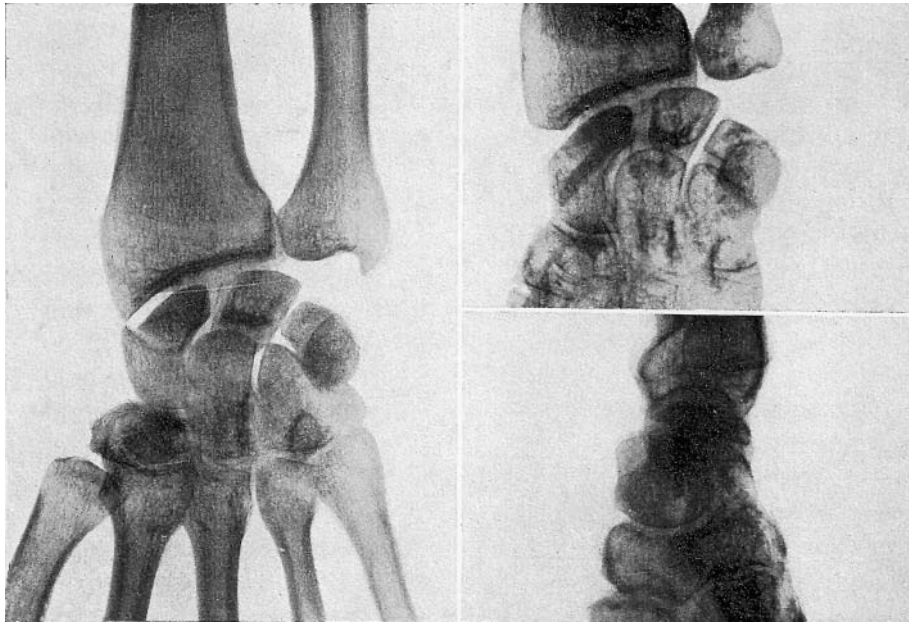


Figure 2 Scaphoid pseudoarthrosis. Result at 3 months from the procedure (radial styloidectomy and implantation of an autologous radial graft harvested from the distal radius).

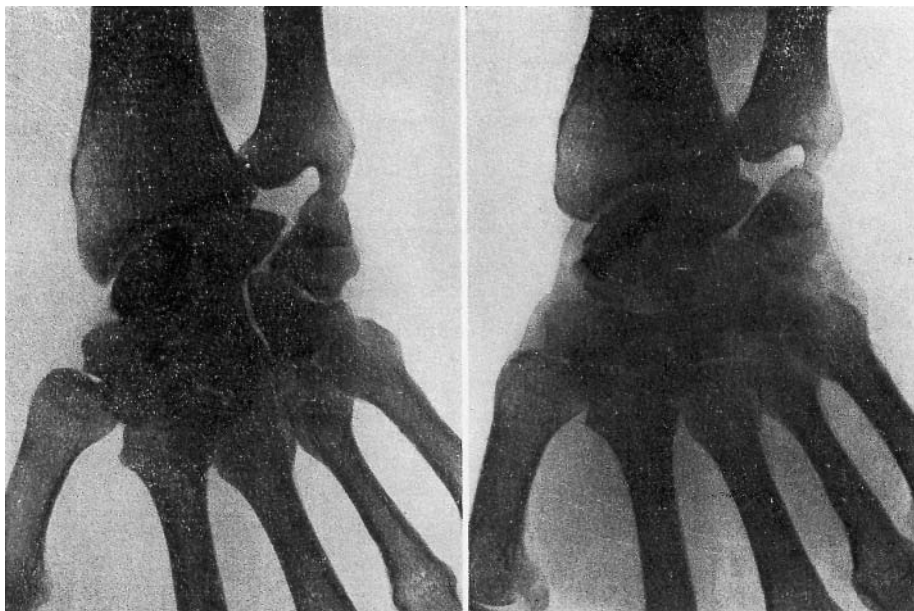


Figure 3 Scaphoid pseudoarthrosis. Result at 5 months from the procedure (radial styloidectomy and screw fixation).

In 2 cases, immobilization was not maintained long enough (25 and 40 days, respectively). In the remaining cases, the wrist was immobilized for 2 months (2 cases), 2 and a half months (2 cases), three months (one case) and three months and a half (one case).

The type of procedure performed was screw osteosynthesis in 6 cases and bone grafting in the remaining 9. In every case, the osteosynthesis was combined with a radial styloidectomy

The technique used was as follows:

With preventive hemostasis, a longitudinal skin incision is made in the anatomical snuffbox, running between the extensor pollicis longus tendon dorsally and the extensor pollicis brevis and the abductor pollicis brevis ventrally. Once the joint capsule is exposed, it is sectioned longitudinally from the base of the styloid process of the radius to the scaphoid tuberosity. By means of the technique described by Bernard and Stubbins, the styloid process of the radius is

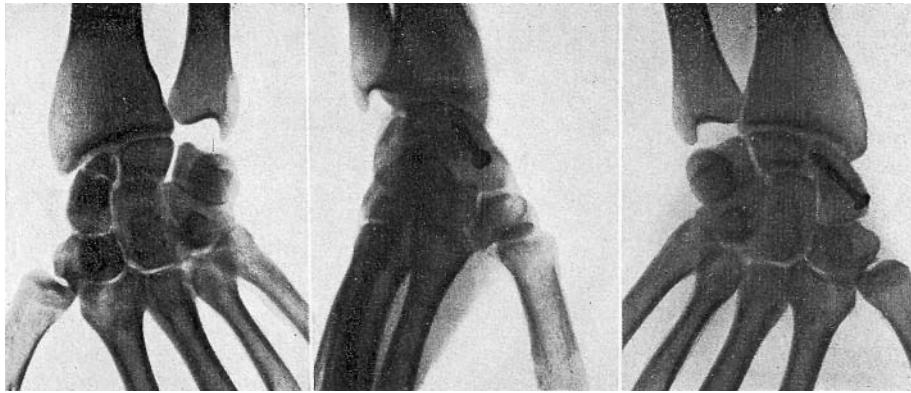


Figure 4 Scaphoid pseudoarthrosis. Result at 5 months from the procedure (radial styloidectomy and screw fixation).

resected in order to prevent the risk of stylo-scaphoid arthritis and thereby avert the potential mechanical action that such arthritis could exert upon the peripheral fragment.

With an awl of 3-4 mm in diameter, a tunnel is driven along the longest axis of the bone, which runs through the pseudoarthrosis site.

When a metal osteosynthesis is performed, a screw whose length has previously been calculated is introduced through the path that was previously prepared. The osteosynthesis must compress the 2 fracture fragments enabling a solid immobilization.

To perform an osteosynthesis with grafting, an oscillating saw is used to take a small dowel of cortical bone of around 3-4 mm in diameter and a length slightly below the greatest scaphoid diameter. The graft is introduced by percussion into the previously driven tunnel so as to promote a strong union between both fragments.

Once hemostasis and plane-by-plane suturing have been achieved, a plaster bandage is applied, which must remain in place for 2 months. Physical therapy must begin at that moment.

Patients were followed up postoperatively at different points in time ranking from 2 months and 6 years. Global results were evaluated according to the data obtained in the clinical and radiological assessments. They were considered optimal when there was no spontaneous pain, radiocarpal joint mobility was normal and healing of the pseudoarthrosis site was achieved. They were regarded as good when there was no spontaneous pain, wrist mobility was one-third less than normal and there were signs of radiological improvement (perfect fragment immobilization, regression of sclerosis, reduction of the pseudoarthrosis line, evidence of progressive bone repair). They were deemed as fair when there was persistence of slight pain, mobility was half of normal and the signs of radiological improvement were scarce. Finally, results were classified as poor when pain persisted at preoperative levels, motion is painful and heavily restricted and there were no signs of radiological improvement.

Global results obtained in these 15 cases have been good in 10 cases; fair in one and poor in 4. As regards the technique performed, in the 6 cases in which screw osteosynthesis was performed, good results were achieved

in 4 cases, with poor results being obtained in the remaining 2. In the 9 cases in which osteosynthesis was combined with bone grafting the results were good in 6 cases, fair in one case and poor in the two remaining cases.

According to our observations, patient age and location of the fracture do not play a major role as far as the final result is concerned. We have conducted a thorough analysis of the failures in order to identify their causes. The time elapsed between trauma and surgery was in these cases 14 months, 3 years, 3 and 4 months, respectively. In one of these cases, the fracture had gone unnoticed and in the other three it was immobilized for 2 and a half months in 2 cases and 45 days in the other. In one case there was severe preoperative radiocarpal arthritis, in another the scaphoid fracture was part of a complex carpal fracture and in another case it was associated to a lunate dislocation, which had gone unnoticed. As regards the surgical technique, in 2 of the poor cases screw osteosynthesis was used, while in the other two an osteosynthesis with autologous grafting.

Analyzing these cases, the following conclusions may be drawn:

1. Metal osteosynthesis associated to a radial styloidectomy can in general terms offer good functional results as they provide the fragments with enough solidity to permit early mobility of the radiocarpal joint. Biologically, rehabilitation of a potential necrotic fragment and, in any case, the healing of the pseudoarthrosis proceed more slowly than with autologous osteosynthesis.
2. Osteosynthesis combined with bone grafting, associated to a radial styloidectomy, offers similar functional results to the previously mentioned technique. The essential difference is that when a bone graft is used biological repair of the pseudoarthrosis occurs sooner.
3. We consider radial styloidectomy, performed as an adjunctive procedure to osteosynthesis, either Metallica or autologous, to be fundamental not only because it prevents microtrauma to the distal scaphoid fragment, but also because it can prevent subsequent radiocarpal arthritis.
4. Metal or autologous osteosynthesis must ensure perfect immobilization and close union of both fragments, which play both a mechanical and biologically restorative function.

5. By virtue of the above, this technique is not indicated for comminuted fractures, or for those fractures where one of the fragments is very small.
6. The time elapsed between trauma and surgery and the prior treatment applied have no influence on the final result. The prognosis of the pseudoarthrosis is much more severe when the radiocarpal joint shows evident signs of osteoarthritis or when the scaphoid injury is associated to other complex carp injuries (associated fractures, lunate dislocations, etc.).

Abstract

On the basis of 15 cases followed-up at the Rizzoli Orthopedic Institute, the authors report on the biological and mechanical conditions that determine and perpetuate delayed healing and pseudoarthrosis of the carpal scaphoid bone as well as on the comparative results obtained by metal and autologous osteosynthesis.

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