Treatment of Carpal Scaphoid Nonunion by Matchstick Bone Graft and Fixation by Bone Cement

M.S. EL ZAHAAR, M.D.

Benha Medical Facility, 9 Asma Fahmy St; 3rd Quarter, Koleat El Banat, Heliopolis Cairo, Egypt

Abstract. This study examines the use of internal fixation of carpal scaphoid nonunion with bone cement in seventeen established nonunions over the course of seven years (1981–1988). Four of the patients in the study were women and eight were men. Both surfaces of the nonunion were freshened up. A matchstick bone graft harvested from the lower end of the epilateral radius was driven in a predrilled tract across the fracture site. Bone cement in a semiliquid state was applied in the crevices of the pseudoarthrosis. Plaster of paris was not applied postoperatively. The average subsidence of post-operative discomfort was three weeks. Original pain at the extremes of wrist movement was not recorded in fifteen patients (88%). Two patients (12%) developed transient swelling and pain in the wrist attributed to the chemical synovitis, which was adequately controlled by local injection of hydrocortisone. Three cases developed radiographic nonunion but were painless at the extremes of movement. All patients returned to their usual activities within 6 weeks of the operation. Although the use of bone cement for the reinforcement of pathological fractures is widely accepted, its application in side joints and the temporary controllable synovitis in two cases is new. The transformation of three cases to painless pseudo-arthritis may be a result of the inert coating of the cement. Bone cement was an apparently reliable internal fixator in fourteen cases in the early phases of natural bone union, a possible indicator of some new potentials for its applications.

Introduction

Many techniques have been reported to have satisfactory results for nonunion of the scaphoid without associated fractures or dislocations of the surrounding bones and/or severe arthritic changes. Bone pegging [1] is a stout graft excised from the olecranon, which has been used to transfixed scaphoid fragments. Bone grafting [2–4] either by bone chips or wedge grafting has also been used to enhance union of scaphoid nonunion. Recently, electricity has been used to stimulate union for scaphoid nonunion [5]. Electric stimulation and immobilization have both proven to augment the healing process.

All of these techniques need plaster fixation of the wrist for a period up to 20 weeks which may proceed to wrist complications such as wrist stiffness and Sudeck’s atrophy.

A modified technique was used in this study to overcome the problem of carpal scaphoid nonunion without the need for prolonged plaster fixation.

Materials and Methods

Seventeen patients of established nonunion of carpal scaphoid fracture participated. The period of nonunion ranged from 8 months to 3 years (average: 2 years and 4 months). All of the patients were unilaterally affected; the right hand was dominant (63%). Ages ranged from 21 to 32 (average: 28.5 years). Four were women and eight were men. Follow-up ranged from 1981–1988 (average: 6.2 years). Radiographic study revealed nonunion of the scaphoid without any wrist arthritic changes.

The method used was a combination of bone grafting and internal fixation with bone cement.

Operative Technique

With general anesthesia and tourniquet control, a dorso-radial exposure of the carpal scaphoid was performed with the protection of the underlying superficial branch of the radial nerve. The dorsal capsule of the joint was entered after excising it longitudinally to observe the nonunion. The unfractured fragments were accurately aligned with the inspection of the area for the arthritic changes.

With the elongation of the same incision proximally to expose the lateral dorsal side of the lower end of the radius and with a tubular gouge, a bone graft was cut along the cortex of the lower end of the radius of sufficient length to be inserted across the nonunion site of the scaphoid.

Drilling through the long axis of the scaphoid from distal to proximal was performed using a drill bit of precisely the same size as the bone graft while the scaphoid was reduced.

Freshening of the pseudoarthrosis was performed with the creation of incomplete drill holes in both scaph-
Fig. 1. Insertion of corticocancellous matchstick bone graft across the fracture. Sticking of both scaphoid fragments by bone cement.

Fig. 2. Exposure and freshening of the scaphoid fracture.

Fig. 3. Insertion of the matchstick corticocancellous bone graft through a predrilled track transfixing the scaphoid.

Fig. 4. The scaphoid bone after sticking with bone cement.

oid fragments around the previous larger one so the graft could be filled by methyl methacrylate (bone cement).

By manipulating the plunger to expel the graft from the tubular gouge, the graft was inserted across the site of nonunion to fit like a stopper.

After the preparation of bone cement, and during its semiliquid state, a small amount was applied in the crevices of pseudoarthrosis and around the stout matchstick bone graft; accurate reduction of the fracture was maintained until the cement hardened.

Closure of the capsule and the skin was followed by a crêpe bandage fixation with volar splint for 2 weeks until the stitches were removed with no need for plaster cast fixation.

Finger active exercises were started on the same postoperative day and followed with periods of active wrist movement through the day after 3 days, with periodic removal of the splint.

The stitches were removed after 10–14 days, followed by the removal of the splint. The patients received physiotherapeutic sittings for wrist and finger mobility and to guard against wasting of the muscles of the hand and wrist.

Pain was assessed subjectively during follow-up, as was painless wrist movement. Radiographs were taken to determine the state of healing of the bone graft and the effect of the bone cement on the scaphoid fragments as well as the conditions of both scaphoid fragments. Wrist stability was observed and recorded and complications with the suitable methods of avoidance were identified and suitably treated.

Results

The average length of postoperative discomfort was 3 weeks. The original pain at the extremes of the wrist
movement was not recorded in 15 patients (88%); this result was considered to be satisfactory. Pain at rest disappeared from all of the patients.

Range of active movements (flexion, hyper-extension, ulnar and radial deviations and circumduction) gradually increased through the period of follow-up and during physiotherapy. Movements became painless after approximately six weeks. Two patients (12%) developed wrist swelling which was neither hot nor red but painful with some limitation of wrist movement. One of these appeared at the end of the third week and the other in the middle of the fifth week. Radiographs showed no recognizable change, and the results of the culture of the aspirate revealed no growth. Wrist swelling was controlled by aspiration and followed by the injection of 40 mg prednisolone suspension, which was repeated after 3 days in one patient.

Recurrence was not recorded in any of the patients in this series.

Radiographic nonunion was diagnosed within 3–4 months in three patients (17.6%) in the painless group: one showed signs of avascular necrosis of the proximal part of the scaphoid; two showed no signs of union with crumbling of the bone graft. Strangely, these cases were painless with little limitation of wrist movements and their power grip, pain and movement were better than before surgical interference.

Power grip of the hand was increased in nearly all cases, although one woman suffered Sudeck’s atrophy and required further physiotherapy.

Neither superficial nor deep infection was recorded in any case. All patients returned to their usual activities within six weeks of the operation.

**Discussion**

Many methods were performed to enhance and treat union of the nonunited carpal scaphoid without fractures or dislocations of surrounding bones or severe arthritic changes.

Bone pegging was originally reported by Armstrong and Butler [1,6] in a series of 90 cases. A peg-shaped bone graft should be inserted down the long axis of the scaphoid to obtain both union and fixation of the scaphoid. This places an excessive demand upon the bone peg, which must be strong enough to support the scaphoid and enhance bony union. Prolonged plaster fixation for 3–5 months, with its consequent wrist stiffness and Sudeck’s atrophy, obviates such a method. Difficulties in placing a large drill in this small bone, which lies in an oblique direction, have also been reported [7].

Collapse deformity tends to prevent adequate apposition of the fractured surfaces of the carpal scaphoid by causing angulation of the scaphoid with the apex dorsally. In these circumstances the scaphoid should be grafted [4]. Russe [2] reported a series of 22 patients, 20 of which had bony union. Mulder [3] reported a series of 100 cases of pseudoarthrosis of fracture scaphoid treated by bone wedge grafting. Ninety-seven cases had bony union. All cases should be fixed in plaster for 8–12 weeks.
Sudeck's atrophy was reported in 32% of Mulder's series and 26% of the Russe group.

Electric stimulation is now a recognizable treatment for scaphoid nonunion. Electricity and immobilization augment the healing process. The contraindications include wrist arthritis, avascular proximal pole, and scaphoid fractures complicated by injuries such as a comminuted fracture of the distal radius. Disadvantages included the prolonged period of immobilization [5].

From the previously described techniques, the main disadvantages are prolonged immobilization in plaster casts followed by Sudeck's atrophy, wrist-wasting, and stiffness. Hence, if there is a method that helps in bone healing and decreases the period of immobilization, it will be of great benefit to the wrist. The use of bone cement as an internal fixator around the bone graft between the two scaphoid fragments may be the goal.

The first reports of the use of methylmethacrylate to
supplement fixation of pathological fractures in metastatic bone disease appeared in the literature in the early 1970s [8].

Histological studies of human bone [9] and canine femora [10] have shown that the trabeculae in contact with methylmethacrylate cement undergo necrosis. A layer of fiber cartilage derived from compressed fibrous tissues forms at the interface between the cement and bone. The endosteal bone undergoes eventual revascularization, although there is vigorous periosteal new bone formation in canines. An early study of fracture healing in the presence of cement by Wiltse et al. [11], which demonstrated that the fracture united and periosteal new bone invested the cement. Similar experiments were per-
Formed in rabbits and sheep by Szyszkowitz and Cockin [12], which revealed extensive necrosis of the bone ends, possibly caused by the exothermic reaction upon polymerization of the cement. However, the fracture united by bridging callus, external to the cement and the dead bone ends were revascularized.

Although the use of bone cement for the reinforcement of pathological fractures is now widely accepted, its application inside joints is new. The bone graft was applied to enhance bone union, while bone cement was used to stick both fragments as a sort of internal fixation. Healing of the fracture through the bone graft was ob-
served in 14 cases, and external union was found around the bone cement in the peripheries of the scaphoid.

Three cases developed radiographic nonunion which was painless at the extremes of wrist movement. Failure of the sticking process of the bone cement (immediate or delayed) created a mechanical barrier preventing painful shearing between both scaphoid fragments. It also coated both fracture surfaces by an insensitive or inert layer rendering the eight carpal bones into nine bones. Benton [13] advised the insertion of a fibrofatty pad at the site of nonunion to prevent the painful shearing between both scaphoid fragments [13].

Two patients (12%) developed transient swelling and pain at the wrist without redness or hotness. Fever was not recorded, and the aspirate was sterile. Such sterile synovitis was adequately controlled by a local injection of hydrocortisone, and was attributed to chemical synovitis.

The advantage of this method of treatment of scaphoid nonunion is that the patients can perform their daily living activities within 3 weeks and they were able to participate in hard work after 6 weeks. Sudeck's atrophy was recorded in one refined delicate lady who refused to perform exercises and physiotherapy. Plaster cast fixation was not required in any of the patients in this series.

The early failure of the sticking process of bone cement is a result that is not harmful; rather, it acts as a mechanical barrier preventing the painful shearing movement between the scaphoid fragments. Also, delayed failure of the cementing process of the methyl methacrylate results in the scaphoid fragments being united by a peg bone graft that maintains the integrity of the scaphoid bone [14].

Bone cement is an apparently reliable internal fixator in scaphoid nonunion as a side bone. Its use during the early phases of natural bone union, may indicate some new exciting potential for its application [15].

References

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