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Results of Scaphoid non-union treated by non-structural cancellous bone grafting and Herbert screw fixation.

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Abstract

Background*: Scaphoid fractures commonly occur in young adult males due to falling on an outstretched hand or as a result of traumatic injury. Delayed treatment can lead to avascular necrosis, delayed union, non-union, and secondary osteoarthritis. Our study is to determine the results of non-structural cancellous bone grafting and Herbert screw fixation in fracture non-union scaphoid.*

Materials and methods*: This prospective interventional cohort study includes 20 patients who underwent surgery for fracture non-union scaphoid. The functional outcome of the patients was assessed based on the Mayo wrist score questionnaire at 6 and 12 months. Range of motion and grip strength was measured using a goniometer and dynamometer respectively.*

Results*: Mean age of patients was 30.4±5.8yrs. The mean duration of fracture union was 9.3±3.4 weeks. The mean Mayo wrist score at 6 months was 79.75±6.58 and at 12 months it was 95.5±3.94 with statistical significance, p<0.001. Among the 20 patients in the study, 15 Patients were rated as excellent, and 5 patients as good at the end of follow-up.*

Conclusion*: Even though the best treatment remains controversial, non-structural cancellous bone graft with Herbert screw fixation is an effective method for the treatment of symptomatic Mack-Lichtman type II scaphoid fracture non-union with excellent functional outcome.*

KEYWORDS: SCAPHOID, HERBERT SCREW, CANCELLOUS BONE GRAFT, MAYO WRIST SCORE, ANATOMICAL SNUFF BOX

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I. Introduction:

Scaphoid bone fractures are the most common carpal bone injury that occurs due to falling on an outstretched hand[1]. Patients with scaphoid fracturesgive complaints of pain and swelling in the anatomical snuff box. These fractures tend to get missed with routine x-ray views of the wrist joint and in addition to this, these fractures tend to have high shear stress and notorious blood supply which further leads to avascular necrosis, delayed union, non-union, and secondary osteoarthritis. Delay in the treatment is also responsible for the scaphoid non-union[2,3]. Acute fractures tend to heal with conservative management in 90% of cases and in 5%-10% of the cases, surgical intervention is needed to address the non-union. Non-union if left untreated leads to carpal collapse, and secondary osteoarthritis and hampers the function of the wrist[2,4,5]. Therefore, it is necessary for these non-unions to be fixed with surgical management. With the recent advances in surgical treatment, the failure rate still remains at 10%[6].

Various surgical treatment modalities have been reported but the ideal modality is yet to be found. These surgical techniques focussed on correcting the deformity by filling the large gaps with bone grafting and fixing them with screws. Various types of bone grafts have been used in filling the gaps which include non-vascularized bone grafts (cancellous bone chip graft, wedge bone graft) and vascularized bone grafts. A handful

of studies have been done regarding the use of non-vascularized cancellous bone grafts and headless screw fixation in scaphoid non-union.

In our study, we used an autologous cancellous bone graft taken from the distal end of the radius from the same side and fixation of scaphoid non-union with Herbert screw. This is a straightforward surgical method involving a single incision for fixation of fracture and procurement of graft, there is no need to shape the graft but requires the impaction of the cancellous graft to fill the gap.

Aims and objectives:

to access the functional outcome of scaphoid non-union treated surgically by non-structural cancellous bone graft and Herbert screw fixation.

II. Material And Methods:

A prospective interventional study was conducted in a recognized tertiary care hospital between November 2020 and January 2022. A universal sampling technique was adopted in this study. The patient cohort consists of 20 patients with non-union fracture scaphoid fulfilling the inclusion criteria were included in the study.

Inclusion criteria:

- Patients aged more than 20yrs who had a scaphoid fracture 3 months before initiation of the study with bone resorption or sclerotic changes on x-rays.
- Mack Lichtman type-2 non-union.

Exclusion criteria:

- Patients with a history of systemic disorders affecting the musculoskeletal system.
- Patients with simultaneous fracture of other wrist bones, and scapholunate dislocation.
- Apparent degenerative changes in the wrist joint on radiology.
- Patients with avascular necrosis of the proximal fragment on MRI.

After obtaining the informed written consent the patients fulfilling the inclusion criteria were included in the study. After routine preoperative workup and pre-anesthetic evaluation patients were posted for surgery (Fig.1). The patient is placed in a supine position with the injured forearm on the side table under the tourniquet pressure of 220mmHg. The palmar approach to the scaphoid was used to get access to the non-union site (Fig.2). Then, 1.5mm k wires were inserted in each of the fragments, and the fracture is distracted. The fibrous tissue and the sclerotic bone within the site of non-union were debrided and curetted. Using a burr until the vascularized cancellous bone was exposed. Using the same incision extending proximally the plane wasmade using a modified henrys approach and physiological splitting of muscle fibers of the pronator quadratus was done thereby exposing the metaphyseal region of the distal end of the radius. Using a 2mm k wire multiple unicortical drill holes were made in a circular fashion over the metaphyseal region of the radius and the removal circular piece of cortical bone was done (Fig.3). An adequate amount of cancellous bone was curetted from the distal end of the radius and replacement of the cortical piece over the defect was done. The non-vascularized cancellous bone graft was then impacted at the non-union site while maintaining its anatomical length (Fig.4).

Fig. 1: Pre-operative Xray showing fracture Non-union scaphoid

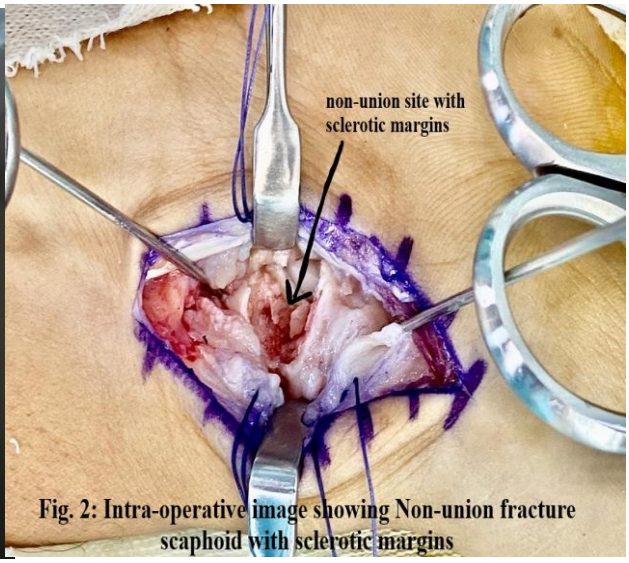

Fig. 2: Intra-operative image showing Non-union fracture scaphoid with sclerotic margins

Then the k wires used for distraction were removed, and the guide pin of a Herbert screw was inserted from the distal fragment and passed through the bone graft site to the proximal fragment under direct vision. An additional k wire was inserted in parallel to the guide pin to prevent the rotation of the fragments. A 2.4mm Herbert screw was inserted to stabilize the scaphoid under the guidance of an image intensifier.

The leading part of the screw was placed in the proximal fragmentwith the threads completely crossing the bone graft. After fixation, the mobility of the wrist joint is checked to note and undue prominence of the screw in the joint (Fig.5)

Fig. 3: Intra-operative image showing graft site (distal end radius)

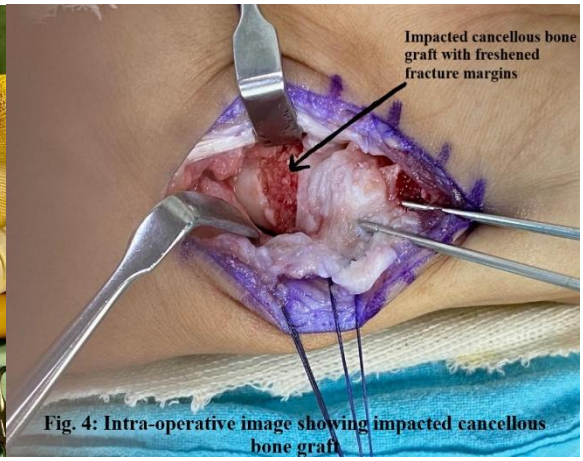

Fig. 4: Intra-operative image showing impacted cancellous bone graft

. The closure of the capsule is done, followed by subcutaneous tissue, and skin closure is done and immobilized with a thumb spica splint. The sutures were removed on the 12th postoperative day and a thumb spica cast is given. Removal of cast and range of motion exercises were started from 6 weeks postoperatively. Return to daily activities was advised once fracture union was confirmed on X-rays during follow-up.

Patients were followed up for a maximum period of 12 months(Fig. 8). The functional outcome of the patients was assessed based on the Mayo wrist score questionnaire at 6 and 12 months. The scoring system consists of questions on pain intensity, functional status, grip strength, and range of motion. Scores are recorded in four groups: 90-100: excellent, 80-90: good, 60-80: satisfactory, and below 60: poor.

The pain was categorized into four levels no pain, mild occasional, moderate tolerable, and severe to intolerable. Physical activity was also categorized as returning to regular employment, restricted employment, and being able to work but unemployed. Range of motion in dorsiflexion, palmar flexion, radial flexion, and ulnar deviation in the affected wrist was measured using a goniometer and was reported as a percentage. Grip strength was measured by asking the patient to squeeze the index finger of the examiner, and the strength was compared on the contralateral side using a dynamometer and reported as apercentage.

Statistical analysis was performed using SPSS (version 18, Chicago, IL, USA). Data are expressed as mean ± standard deviation for numerical variables and as percentages for categorical variables.

III. Results:

The following results were obtained from the study conducted on 20 patients with ages of the patients ranging from 22yrs to 46yrs. The mean age group of the patients was 30.4±5.8yrs. Among 20 patients, 16 were male, and4 werefemale. The average time interval from trauma to surgery was 4.5±1.19months (Fig.6). There was no case of bilateral scaphoid fracture non-union in our study. No patients were lost to follow-up.

The duration of fracture union ranged from 6 weeks to 16 weeks with a mean union duration of 9.3±3.4 weeks. The range of motion of the wrist at the last follow-up improved compared to the preoperative condition: dorsiflexion from 60^0 to 73^0, palmar flexion from 58^0 to 71^0, radial deviation from 14^0 to 18^0, and ulnar deviation from 32^0 to 35^0 (Fig.7). In the preoperative period, the mean Mayo wrist score was 56.25±6.25

out of 100 showing substantial functional disability due to non-union. The mean Mayo wrist score at 6 months was 79.75±6.58 and at 12 months it was 95.5±3.94(Fig. 9), showing significant improvement in the functional outcome.

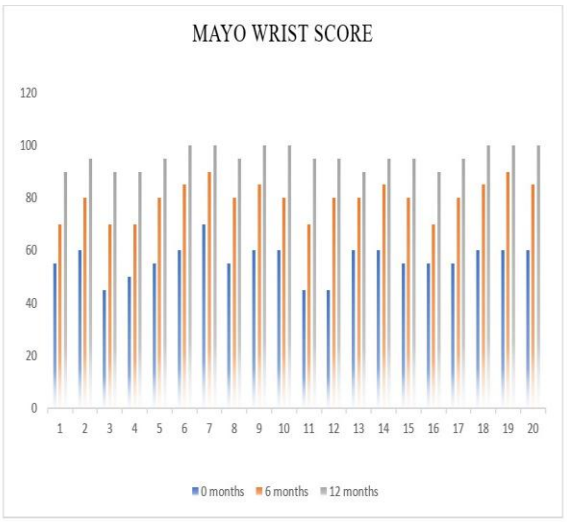

Fig. 8: Mayo Wrist Score of twenty patients at 0, 6, 12 months.

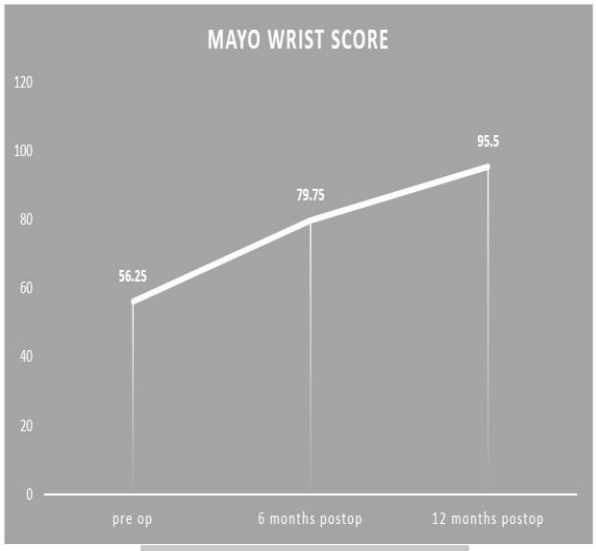

Fig. 9: Mean Mayo Wrist Score

The statistical analysis was done using an unpaired t-test and statistical significance, $p<0.001$ was established. Among the 20 patients in the study, 15 Patients were rated as excellent, and 5 patients as good at the end of follow-up. There were no cases of surgical site infection, screw penetrating into the joint, screw cut-off, and donor site-related problems.

IV. Discussion:

In the current study, we assessed 20 patients with non-union scaphoid fractures who underwent non-vascularized cancellous autograft harvested from the distal end of the radius and fixed with a headless screw. The results were good to excellent based on the mayo wrist scoring. We believe that these results were due to the restoration of normal anatomical alignment and the accomplishment of bony union.

Watson *et al*. in their study described a dorsal approach for scaphoid and addressed non-union with cancellous bone graft and k-wire fixation. Union was achieved in 85% of cases, flexion and extension averaged 76% of the contralateral side, and grip strength of 88%[7]. Nagle *et al*. did a similar study using the volar approach to the scaphoid and addressed the non-union with morselized cancellous bone graft and k-wire fixation, which showed similar results. Nagle also pointed out that the cancellous morselized graft could be manipulated more easily and precisely than the corticocancellous graft to fit the scaphoid defect[8].

Bullens*et al*. in their study found symptomatic scaphoid non-unions treated by a simple, minimally invasive procedure using a percutaneous autologous corticocancellous bone graft were evaluated after an average follow-up of 3.5 yrs. None of the patients had pain in routine activities and had an almost normal grip strength and range of motion and no progression of osteoarthritis was observed[9]. In our study, with a minimally invasive approach and using a cancellous bone graft from the distal end of the radius, and fixation with a headless screw we are able to achieve 100% fracture union at 9.3±3.4 weeks. At 12 months follow-up, all the patients in our study had near normal range of motion and grip strength.

In the current scenario, authors prefer cancellous bone grafts using autologous cancellous bone grafts harvested easily either from the iliac crest or from the distal end of the radius. Park *et al*. reported that pure cancellous chip bone harvested from the iliac crest had both the osteogenic features required for osseous integration and sufficient initial strength to resist the physiological load[10]. However, lateral femoral cutaneous nerve injury and abdominal hernia associated with iliac crest bone harvesting still remain possible complications[11]. In our study, we used an autologous cancellous bone graft harvested from the distal end of the

radius, and 100% bony union was achieved in 9.3±3.4 weeks and excellent functional outcome (95.5±3.94) was achieved in patients with a span of 12 months, implying similar osteogenic potential and sufficient initial strength to maintain the physiological load and anatomical alignment. Since addressing non-union scaphoid and harvesting of the graft was done with a single incision using the volar approach, the duration of surgery and complication rate has been further decreased.It also neutralized the second incision (for graft harvesting) related burden on the patient.

Bertelli*et al*. in their study reported patients with the scaphoid non-union present for longer than two years, who were treated using a vascularized bone graft harvested from the thumb and pedicled on the first dorsal metacarpal artery by a palmar approach showed 90% of the bone union at one-year follow-up with significant pain relief and improvement in range of motion and grip strength[12]. Our study showed almost similar results except our study population had non-union for a period of 4.5±1.19 months since injury and we were able to achieve 100% union at 9.3±3.4 weeks.

A headless self-compression screw is commonly used for the fixation of fractures and grafts. It is buried under the articular surface and provides a stronger fixation. One study reported that screw fixation was superior to k-wire fixation in an unstable scaphoid non-union[13]. In our study, we used a headless self-compression screw for stable fixation of fracture fragments and cancellous graft which further aided us in maintaining the anatomical alignment. However, when the bone stock is not enough, in cases such as distal or proximal scaphoid non-union or proximal pole avascular necrosis, another method should be considered.

The main drawback of this study was, the number of patients was relatively small and the follow-up duration was limited to 12 months.

V. Conclusion:

In conclusion, an amalgamation of thorough curettage of the sclerotic bone, impaction of the cancellous bone graft taken from the distal end of the radius, and rigid internal fixation with Herbert screw provide an excellent treatment for scaphoid non-union. This plan of treatment aids in maintaining anatomical length, and correction of deformity and provides excellent functional outcomes.

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