Research Article

Use of Drill Extract as Osteoconductive Bone Graft in Internal Fixation of Fracture of Long Bones

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Abstract |

Background: The purpose of this study was to review the results of using bone chips as bone grafts in the management fractures of long bone. This autologous bone graft was harvested from the part of the healthy bone just adjacent to the fracture site by surgical drilling for the purpose of internal fixation. This technique of collection of bone pieces and their utilization is novel as no previous study on this technique is found in the literature.

Methods: This was a quasi-experimental study conducted between August 2012 and February 2014. Total one hundred and two patients of long bone fractures were rigidly fixed internally on standard AO principles in King Edward Medical University/ Mayo Hospital, Lahore. In all these cases surgical drill extract was used as bone graft and was placed at the fracture site. Each operation was performed by the same surgical team. Healing was determined radiographically by the presence of trabeculations across the fracture.

Results: Majority 87 % of the operated fractures showed sign of healing after 12 weeks and 100% of fractures healed after 16 weeks. No patient included in the study showed signs of nonunion and deep infection.

Conclusion: Bone graft harvested from the native bone by surgical drill bit can be used e   ciently in the management of long bone fractures in conjunction with the rigid internal fixation.

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Introduction

Autogenous bone graft is frequently used since 1900[1] Bone grafting is the second most common transplanted tissue in the human body.[2] Blood transfusion being the most commonly transplanted tissue with platelet and fresh frozen plasma has 21.24 unites and 8.64units per 1000 respectively.[3] Bone grafts are either osteoconductive, or they are osteogenic.[4] The acquisition of autogenous bone increases operative time and the donor site morbidity. Donor site complications and procurement morbidity can result in increased patient recovery time, disability,[5] and chronic pain at the bone graft donor site (9%) incidence of chronic pain following lumbar spinal fusions.[6] These complications can be avoided by using the drill extract.

Data reported the percentage of cells that remain viable in transplantation is unknown but, these viable cells seem to be improved by minimizing the interval between harvest and implantation and by keeping the graft moist and at physiologic temperatures.[7,8] The drilling of bone is an integral part of orthopaedic surgery and majority of the surgical procedures done involve this. To accommodate a screw for rigid fixation, a cylindrical tunnel is prepared in bone using a surgical drill bit and as a result, fragments of bone are extracted from the prepared tunnel. In this study, the collective mass of these fragments from several tunnels was used as bone graft in the management of fracture of long bones and the outcome was evaluated.

In this study we evaluated the outcome of autologous osteoconductive bone graft harvested by a novel surgical technique i.e. drilling of bone.

Methods

This quasi experimental study was done using non-probability convenient sampling technique was conducted in the Department of Orthopedic Surgery Unit II, King Edward Medical University/ Mayo Hospital, Lahore. Our sample size was 76 patients with 102 fractures of long bones who presented in the accident and emergency department and were operated upon within 02 days of admission after optimizing the patients for anesthesia. All skeletally mature patients were included in the study. Close fractures and Gustilo and Anderson type 1 open fractures presenting within twenty-four hours of injury were also included in the study. Patients having pathological fractures, open fractures Gustilo type II and above and having atrophic non-union were excluded from the study. All fractures were internally fixed with plates and screws on standard AO principles. Plates used were dynamic compression plates, locking plate, buttress plate or the recon plate depending on the regional requirement. Functional outcome in upper limb were assessed using Quick-DASH score[9] and in lower limb it was assessed using American knee society score.[10] Following procedure was performed:

For 4.5mm screws, 3.2mm drill bit was used and for 3.5mm screws 2.7mm drill bit was used. Pneumatic drill machines and battery driven electric machines with rpm not more than 1000 were used. Bone pieces extracted from the surgical drilling of the bone for accommodation of screws were carefully collected from the drill site by plain forceps (Figure 1). Saline irrigation during drilling to lower the local temperature was not used. The pieces of bone in the drill flutes were also collected after each drilling. The bone mass which was collected from each hole was added together to make a semi-solid cement like tissue and was applied over the fracture site after the end of internal fixation and before the wound closure (Figure 2). It was made sure that washing of the wound was done prior to its application at the fracture site.

Patients were followed on regular basis and standard postoperative protocol was followed i.e. early range of motion exercises and weight bearing according to the healing response. Stitches were removed on the 10th postoperative day and further follow up was done on 4th, 8th, 12th and 16th postoperative week and radiographs were taken to assess the bone healing. Presence or absence of healing response was documented on the Performa.

Data were entered and later analyzed using SPSS version 20.0. Quantitative variable i.e. age, quick dash score and union time in upper and lower limb bones were presented as mean±SD.Qualitative variables like gender, fracture of the bone were calculated as percentages and frequencies. Independent sample t test was applied to compare the union in upper and lower limb bone fracture.

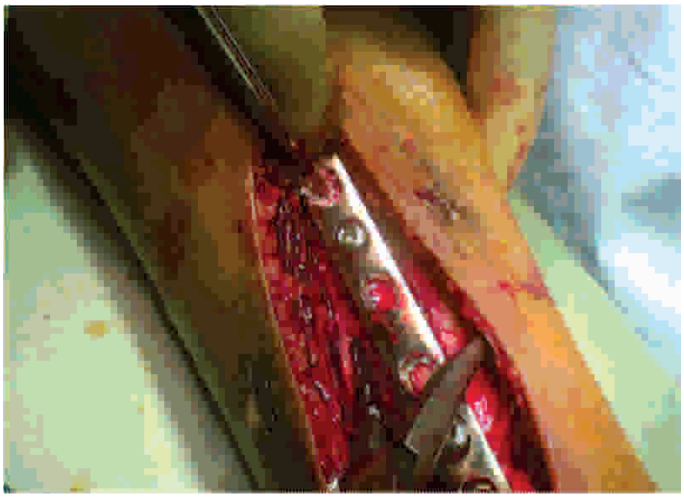

Figure 1: *Shows Bone Pieces Extracted from the Surgical Drilling of the Bone for Accommodation of Screws.*

Figure 2: *Drill of Flutes Mixed with Semi-Solid Bone Cement like Tissue that was Applied Over Fracture Site*

Results

A total of 76 patients with 102 fractures of long bones were included in the study. Only 9.5% of the patients had fractures of more than one site. Forearm fractures were considered to be single site, but combined radius and ulna fractures were considered as two separate long bones as both needed fixations separately. Most 61(81%) were male and 15(19%) patients were female. The age of the patients ranged from 16 to 62 with the mean age of 33±8.641year. Motor vehicle accident (MVA) was the most common mode of injury Table 01. Out of total of 102 fractures, 34 (33.3%) were fractures of shafts of Radius and Ulna combined, 32 (31.3%) were fracture of shaft of Tibia, 18 (17.6%) were fracture of shaft of Humerus, 07 (6.8%) were fracture clavicle, 06 (5.9%) were fracture of fibula which needed fixation along with fracture of tibia, 04 were isolated Radius (Galeazzi) fracture and 01 was isolated Ulna (Monteggia) fracture Table 02.

Amongst 89 fractures, majority (87%) showed sign of union at 12 weeks follow up and all the fractures showed radiographic sign of union at 16 weeks follow up. Most (13%) had fracture union at 18th week of follow up. The mean union time in lower limb fracture was 17.985±4.857 and mean union time in upper limb fracture was 16.081±3.983. In upper limb functional outcome was measured using Quick-dash score and mean quick Dash score was 14.8±7.8. Post-operatively American knee society score was excellent in 23 (63.9%), good in 07 (19.5%), fair in 05 (13.9%) and poor in only 01 (2.7%) patient Table 01. Independent sample t test was applied and it was significant for union time in upper limb and in lower limb (p-value <0.001) Table 03.

Table 1: *Demographic Data, Union, and Implant Failure.*

Variables	Frequency (N=76)	Percentage (%)
Gender of the patients		
· **Male**	61	81%
· **Female**	15	19%
Mean Age of the patients (years)	33±8.641year	
Mean Union Time in upper limb fractures (Mean±SD)	17.985±4.857	
Mean Union Time in lower limb fractures (Mean±SD)	16.081±3.983	

Table 2: *Fracture of the Bone*

Variables	Frequency (N=102)	Percentage (%)
Fracture of the bone		
· **Radius and ulna**	**34**	**33.3%**
· **Tibia**	**32**	**31.4%**
· **Humerus**	**18**	**17.6%**
· **Clavicle**	**07**	**6.8%**
· **Fibula and tibia**	**06**	**5.9%**
· **Gleazzi Fracture**	**04**	**3.9%**
· **Monteggia Fracture**	**01**	**1%**

Table 3: *Independent Sample T Test of Union Time in Upper and Lower Limb Fractures*

Variables	n	Mean	Standard Deviation	t	p-value
Union Time in weeks in upper limb bone fractures	64	17.985	4.857	16.674	0.001
Union Time in weeks in lower limb bone fractures	38	16.081	3.983	16.204	0.001

Discussion

Drilling of bone is a necessity in many procedures in Orthopedic surgery, particularly in rigid internal fixation of fractures of long bones. Bone is an anisotropic, viscoelastic and porous structure and therefore surgical drilling environment is far di erent from customary drilling of construction.[11,12]

Mechanical energy of the moving drill bit causes friction at the drill bone interface, shear failure of bone and ultimately plastic deformation.[13-15] The bony tissue extracted in this process of deformation is termed as the 'bone dust' or the 'bone extract' by the authors and collected material was utilized in this study as bone graft. (Figure 1 and 2)

The yield of this material depends on a number of factors but the primary area of concern is the magnitude of the temperature elevation in this process. Conversion of mechanical energy of the drill into thermal energy causes transient elevation in the temperature of the surrounding bone and the soft tissue.[16]

Rise in the temperature is determined by a number of factors which include the drill bit geometry, axial thrust force, speed of rotation (rpm), orthotopic site, sharpness of the cutting edges, clogging of flutes during drilling and cooling mechanism i.e. saline irrigation.[17] Time duration of the elevated temperature above a critical point is also a very important variable in the yield of drill dust graft. The abnormally raised temperature can have disastrous e ects not only on the extracted material but also to the native bone where implant has to be anchored.[11]

There is yet no definitive method applied which would exactly calculate the degree of elevation of temperature in the process of drilling in the living bone nor there is a consensus about the critical level at which osteonecrosis develops. Some believe that a temperature of 50 degrees maintained for 30 seconds can cause cell death,[18] while others determined that 47 degrees maintained for 60 seconds can lead to osteonecrosis of the area.[19]

There are certainly limitations in measuring the highest temperature attained' during drilling of bone intra-operatively on patients but experiments have been done on bovine, ovine and cadaveric models. Association of speed of the drill, time duration, sharpness of the bit, axial thrust etc. have been determined. Matthews and Hirsh documented maximum temperature to exceed 100 degrees while drilling the femur of cadaver with 3.2mm drill bit. They found that increasing the speed of the drill bit from 345 to 2900 rpm have little e ect on maximum heat attained but increasing the axial thrust from 20 to 120 N can decrease the maximum heat attained.[19]

Amidst the huge work on temperature elevation during surgical drilling, determination of viability of living cells in the bone chips extracted in the process of drilling is an area where work has yet to be done. It needs a specialized research laboratory with microbiology experts, which is deficient in our local setting. Apparently, the amount of heat generated due to friction is less likely to leave cells alive in the extract. However, cortex of the bone is a biphasic substance with organic and inorganic phases (collagen and hydroxyapatite). Most 60% of the heat generated during drilling is dissipated by the drill extract which is quite less than that dissipated in a monophasis substance like metal, in which 80 % of heat is estimated to be dissipated by the metal chips.[7] Therefore, there exists a possibility for the drill extract to have living cells and viable proteins and therefore may have some retained osteoinductive and osteogenic property. To achieve the e ective and timely union, additional factors of nutritional status, sound mechanical stability and biological factors are also necessary.[20,21]

Nonetheless, we have tried to evaluate its property in our clinical setting and keeping in view the literature regarding the heat generation we have considered the use of bone drill extract as osteoconductive only. Its use in our clinical setup has produced very good results in our limited study but it is yet to establish whether this good outcome is attributed to adherence to AO principles strictly, minimal soft tissue dissection or the use of drill extract as the bone graft. This can be clarified by further research work on the same field and authors are working on comparative study of fixation of long bones with and without the utilization of drill extract. The quest for the biological analysis of the extracted bone chips by drilling is also in progress.

Conclusion

Drill extract during internal fixation of long bones can be used e ciently as osteoconductive bone graft in the management of fractures of long bones.

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Conflict of Interest: None
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