Original Article

The Use of Calcium Phosphate for Defect Augmentation in Tibial Plateau Fractures

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Abstract

Metaphyseal fractures like Tibial plateau fracture are often associated with bone defects and sub-chondral voids which need to be filled along with fixation of the fractures. Autologous bone grafting was considered as the 'Gold Standard' in filling such bone defect but the associated complications had lead the surgeons to seek alternative options. Calcium Phosphate compounds are highly biocompatible bone substitutes and can be used effectively and safely in Tibial Plateau fractures as an alternative to the autologous bone grafting.

The objective of this study was to determine the outcome of Calcium Phosphate used in maintaining an anatomical reduction in tibial plateau fractures with bony defect requiring augmentation. The Outcome was determined in terms of fracture union and articular subsidence (collapse of articular surface post-operatively).

Total 40 patients, 18 to 50 years of age, meeting the inclusion criteria, were admitted through the Accident and Emergency department of Mayo Hospital and prepared for surgery. Calcium phosphate bone graft substitute, TCH®, a biphasic ceramic containing hydroxyapatite and tricalcium phosphate, was arranged preoperatively. Open reduction and internal fixation of proximal tibial fracture was done by a single surgeon and quantity of Bone Graft Substitute was determined preoperatively by the surgeon. Thirty seven patients out of 40 (92.5%) achieved complete union at the end of 24 weeks and only 4 patients (10%) developed articular subsidence at the operated site. The authors concluded that the bioresorbable Calcium Phosphate materials such as biphasic calcium phosphate ceramic, appears to be a good choice for the treatment of subarticular defects in tibial plateau fractures. Therefore, it can be used safely and efficiently as an alternative to the conventionally used autologous bone graft in such fractures.

Key Words: Calcium Phosphate, defect augmentation, tibial plateau fractures.

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Introduction

Fractures around the knee joint are common in patients brought to Accident and Emergency department and account for 6% of trauma admission in orthopedic surgery. Tibial plateau fractures involve the tibial articular surface of knee.[1] These fractures are usually associated with variable degree of bone loss. For the anatomic reconstruction of the joint and the defect augmentation such fractures often require bone graf-

ting in addition to open reduction and internal fixation.[2]

Different options for grafting have been proposed. Autologous bone grafting remains the gold standard, as its capability for osteoconduction and osteoinduction combined with the presence of osteogenic cells make it highly effective.[3] Unfortunately autologous graft is associated with donor – site morbidity, additional surgery, increased operation time, patient related problems such as inconsistent volume and quality of the graft and risks the possibility of iatrogenic infection.[4] Morbidity associated with the harvest of autograft has caused many surgeons to use synthetic bone substitute as an alternative to the autograft.[5]

Bone substitute has several potential benefits over autograft. A relatively unlimited volume of uniform quality graft is available without donor – site morbidity. Although there may be some difficulty with handling, bone substitute provides excellent structural properties.[6]

Calcium Phosphate synthetic substitutes are osteoconductive substances which increase bone formation by providing a biocompatible scaffold for the host osteogenic cells to create bone under the influence of host osteoinductive factors.[7]

This study is designed to find a good alternative for the patients requiring autologous bone graft for augmentation of bony defects in tibial plateau fractures keeping in view the complications associated with autologous graft.

Material and Method

A case series was studied in the Department of Orthopedics and Spine Surgery, Unit II, Mayo Hospital, Lahore from July 2009 to July 2010. Forty cases of Tibial Plateau fractures treated with Calcium Phosphate for defect augmentation were studied. Inclusion Criteria were; Patients of either sex aged between 16 to 50 years presenting within one week of injury. Closed and unstable tibial plateau fracture, Shatzker type I through VI (Fig. 1) that requires both internal fixation and grafting assessed radiographically. Exclusion Criteria; Patients with metabolic bone disease, prior tibial plateau surgery and Rheumatoid and other inflammatory arthritis diagnosed on history, clinical examination and previous investigations done.

Data Collection Procedure

Forty patients fulfilling the inclusion and exclusion criteria, admitted from emergency department of Mayo Hospital, Lahore included in the study were informed preoperatively about the nature of the disease, anesthesia, surgical procedure, cost of the bone substitute and complications regarding both anesthesia and surgery. Patient data included name, age, gender, weight, height and address. Fractures were classified according to Schatzker fracture classifications. Informed consent was obtained to use their data in research.

After acute management all fractures underwent open reduction and internal fixation with use of plate or screw fixation technique in accordance with the surgeon's choice and normal practice. Plate and screw constructs were used in 28 patients and screws only were used in 12. All patients were operated by a single surgeon. After reduction of the fracture and restoration or the articular surface, the residual subchondral defect was measured, followed by packing of the space with TCH, a bone graft substitute.

TCH is a macroporous biphasic resorbable ceramic composed of 75% hydroxyapatite and 25% tricalcium phosphate. It was utilized in granular form with size 2 – 3 mm and mean pore diameter of 200 – 500 µm which is compatible with human bone-cell size. The estimated volume of TCH used was approximately 10 grams in most patients.

Postoperative motion was initiated immediately and progressively increased over a period of weeks. Weight bearing was delayed for 10 weeks and was permitted on the basis of the surgeon's judgment.

Follow-up

Six months follow-up data were available for forty patients (100%). Clinical and Radiographic evaluations were performed to assess fracture union and presence or absence of articular subsidence at each follow-up visit i.e. at 3, 6, 12 and 24 weeks after surgery. The findings were collected through a performa (attached).

Data Analysis

After entering the data in the SPSS version 10, it was analyzed through its statistical program. The variables to be analyzed included age (mean and standard deviation were calculated). Gender, presence or absence of fracture union and articular subsidence were presented by calculating frequency and percentages.

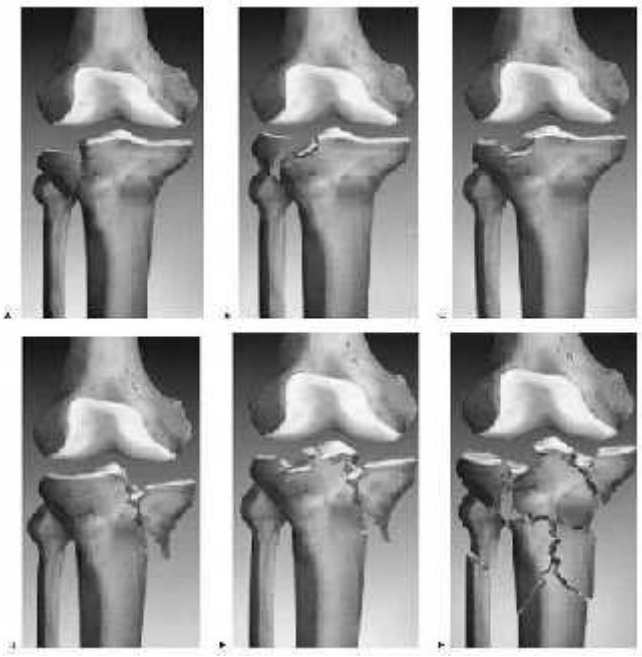

Fig. 1: Schatzker's Classification of Tibial Plateau Fractures A: Type I, B:Type II, C:Type III, D:Type IV, E:Type V, F:Type VI
(Courtesy: Rockwood and Green's Fractures in Adults 6th Edition)

Results

In this study, 40 patients meeting the inclusion criteria, were operated upon using the calcium phosphate bone graft substitute and followed up regularly for 24 weeks. The study was conducted in Orthopedic and Spine Surgery Unit II, Mayo Hospital, Lahore.

There were 30 males (75%) and 10 females (25%). Male to female ratio was 4:1 (Table 1). The average age of the patients was 35.65 ± 8.55years (Table 2).

37 patients out of 40 (92.5%) achieved complete union at the end of 24 weeks (Table 3) and only 4 patients (10%) developed articular subsidence at the operated site (Table 4).

Table 1: Descriptive Statistics of Gender.

Gender	Frequency	Percentage
Male	30	75%
Female	10	25%
Total	40	100%

Table 2: Descriptive Statistics of Age.

Mean	35.65
S.D	8.55
S.E	1.35
Minimum	18
Maximum	50
Range	32

S.D: Standard Deviation
S.E: Standard Erro

Table 3: Frequency table of Fracture Union at the end of 24 Weeks.

Union	Frequency	Percentage
Yes	37	92.5
No	3	7.5
Total	40	100

Table 4: Frequency Table of Articular Subsidence after 24 Weeks

Subsidence	Frequency	Percentage
Absent	36	90%
Present	4	10%
Total	40	100%

Discussion

The surgical treatment of subarticular bony defect in tibial plateau fractures includes bone grafting along with the open reduction and internal fixation of the fracture. Autogenous bone graft, mostly taken from the iliac crest, is considered to be standard because of its osteoinductive capacity, low cost, availability and histiocompatibility.[8] However, iliac bone graft procurement requires second surgical procedure and is associated with morbidity of the uninjured site, i.e. the donor site morbidity.[9-11] Silber et al[12] in a study of 134 patients, found that rate of functional impairment ranged from 7% (from household chores) to 13% (for walking) at an average of four years after autologous iliac bone grafting.

Russell et al[13] compared autogenous bone graft

and calcium phosphate cement for defect augmentation in tibial plateau fractures and found significantly higher rate ($p = 0.009$) of articular subsidence during the three to twelve – month follow-up period in the bone graft group.

The present study included the radiologic follow up and this had limited the study. Thirty seven out of 40 patients achieved complete union of the tibial plateau fracture in the presence of Calcium Phosphate bone graft substitute (92.5%). This percentage is significant and depicts the safety of the synthetic product which is used to fill the bone defect.

A small number of patients in this study developed articular subsidenc at the end of 24 weeks follow-up period. This was revealed radiologically i.e more than 2 mm of depression or subsidence of the reduced articular fragment on plain radiographs. Thirty six out of 40 patients (90%) had no articular subsidence. This high percentage again favors the usage of calcium Phosphate and depicts the effective mechanical support which this material provides.

Better follow up would have included the range of motion data from physical examination. Post operative computer tomography scan was not obtained as this was not considered the standard of care in any of the study sites, but they may have allowed a more accurate determination of the amount of subsidence. In this study, identification of > 2 mm of subsidence in the post-operative radiographs was required before it was considered present and therefore small amount of subsidence was difficult to quantify on plain radiographs.

There is no convincing study available which relates the amount of articular subsidence to the development of osteoarthritis. However, any material which is used to prevent this subsidence must be effective in this function to justify its continued use.

The use of calcium phosphate compounds as bone graft substitutes in the management of fractures is gaining popularity. It is entirely possible that within the next 10 to 15 years, the majority of "bone grafting" in craniofacial reconstructive surgery and in orthopedic surgery may be done with biologically active synthetic bone graft substitutes rather than natural bone sources. In fact, the harvesting of autogenous grafts may eventually prove to be the exception rather than the standard of care. Efforts are being done to overcome the limitations like low mechanical strength in shear, bending and tension.[14]

Mechanical strength can be improved by adding fiber in the synthetic compounds. The resorption of the fibers is faster than the calcium phosphate it is mixed with and this leaves canals in the calcium phosphate which mimic large pores and thus resorption speed can be increased. The fiber reinforcement therefore, not only can increase the strength, it can also increase the speed of resorption.

Calcium phosphate compounds also have a great potential to be used as carriers of therapeutic compounds like antibiotics and bioactive compounds like BMPs. Addition of osteoconductive materials can enhance the capabilities and utilization of calcium phosphate tremendously and can eliminate the use of autograft.

Conclusion

The results of this study indicate that calcium phosphate ceramic bone graft substitute can provide adequate articular support and fills the defects effectively in the treatment of defects in unstable fractures of the tibial plateau. Therefore, it can be used safely and efficiently as an alternative to the conventionally used autologous bone graft in such fractures.

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