Outcomes of osteoporotic trochanteric fractures treated with cement-augmented dynamic hip screw

Rakesh Kumar Gupta, Vinay Gupta, Navdeep Gupta

ABSTRACT

Background: Dynamic hip screw (DHS) has been the standard treatment for stable trochanteric fracture patterns, but complications of lag screw cut out from a superior aspect, due to inadequate bone anchorage, occur frequently in elderly osteoporotic patients. Polymethylmethacrylate (PMMA) has been used as an augmentation tool to facilitate fixation stability in cadaveric femora for biomechanical studies and in pathological fractures. However, there are very few reports on the utilization of PMMA cement to prevent these complications in fresh intertrochanteric fractures. A prospective study was conducted to evaluate the outcome and efficacy of PMMA augmented DHS in elderly osteoporotic patients with intertrochanteric fractures.

Materials and Methods: The study included 64 patients (AO type 31-A2.1 in eight, A2.2 in 29, A2.3 in 17 patients, and 31-A3.1 in five, A3.2 in three, and A3.3 in two patients) with an average age of 72 years (60−94 years) of which 60 were available for final followup. PMMA augmentation of DHS was performed in all cases by injecting PMMA cement into the femoral head with a custom-made gun designed by the authors. The clinical outcome was rated as per the Salvati and Wilson scoring system at the time of final followup of one year. Results were graded as excellent (score > 31), good (score 24−31), fair (score 16−23), and poor (score < 16).

Results: Fracture united in all patients and the average time to union was 13.8 weeks (range 12−16 weeks). At an average followup of 18 months (range 12−24 months), no incidence of varus collapse or superior screw cut out was observed in any of the patients in spite of weightbearing ambulation from the early postoperative period. There was no incidence of avascular necrosis (AVN) or cement penetration into the joint in our series. Most of the patients were able to regain their prefracture mobility status with a mean hip pain score of 8.6.

Conclusion: Cement augmentation of DHS appears to be an effective method of preventing osteoporosis related complications of fracture fixation in the trochanteric fractures. The technique used for cement augmentation in the present study is less likely to cause possible complications of cement augmentation like thermal necrosis, cement penetration into the joint, and AVN hip.

Key words: Dynamic hip screw, fractures, osteoporosis, polymethylmethacrylate, trochanteric

INTRODUCTION

Surgical management of trochanteric fractures aims at restoring the prefracture functional status of patients as soon as possible, to avoid problems of prolonged recumbency. However, primary stabilization with dynamic / sliding hip screw is not always successful, especially in osteoporotic fractures. Low bone mineral density and thin cortices are not only major risk factors for hip fractures, but also contribute to the failure of fracture fixation in elderly patients on account of excessive collapse and lag screw cut-out from the superior aspect.1−3 Internal fixation in such a situation may achieve a satisfactory initial fracture site reduction, but late fracture collapse into varus during weightbearing, can lead to a high failure rate.4 Mechanical stability after fixation in these fractures is dependent on the quality of bone, fracture personality, quality of reduction, and choice of implant5 In the past, various methods such as valgus osteotomy, valgus reduction with tension-band wiring, lateral wall reconstruction, and a variety of other techniques have been developed, in an attempt to reduce the rate of complications in the management of these fractures.5−9 However, none of these have been able to completely address the problem of implant failure in osteoporotic patients, due to a superior screw cut out.8,9 PMMA cement has been successfully used previously for structural augmentation of unstable
trochanteric fractures but the technique has not gained wide acceptance due to associated complications like delayed union and nonunion.9-12

We undertook a prospective study to evaluate the outcome and efficacy of PMMA augmented DHS in elderly osteoporotic patients with trochanteric fractures.

**Materials and Methods**

This prospective study comprised of 64 trochanteric fractures in 64 consecutive patients, more than 60 years of age, and of either gender. Exclusion criteria included patients with an open fracture, subtrochanteric fracture, intracapsular neck of femur fracture, pathological fractures, and associated other fractures of the lower limb preventing early ambulation. A dual-energy X-ray absorptiometry (DEXA) scan of the contralateral hip was done to ascertain the bone mineral density and only patients with established osteoporosis (T score < 2.5) were included in the study.

All fractures were classified on the basis of AO Muller classification (AO type 31-A2.1 in eight, A2.2 in 29, A2.3 in 17 patients, and 31-A3.1 in five, A3.2 in three, and A3.3 in two patients). Informed consent was obtained from all patients. All surgeries were performed on the fracture table with patients in the supine position. Closed reduction was done in most of the cases (n = 52). Open reduction was performed in 12 patients in whom closed reduction failed (two attempts), either due to button holing of fragments in a capsule or iliopsoas muscle or in patients with surgical delay (> 10 days), on account of delayed presentation to the hospital, or medical comorbidities. After achieving reduction and confirming the neck shaft angle under image intensifier, appropriate guide wires were passed, followed by triple reaming and tapping. PMMA bone cement of 10–15 ml was mixed and placed in a custommade gun in a semi liquid state. Under fluoroscopic control, the long barrel of the gun filled with semi liquid cement, was inserted as far as possible into the hole in femoral head over the guide wire. Approximately 4 – 5 ml of cement was injected by inserting the piston into the hollow of the barrel to push the cement into the femoral canal. As the piston was pressed, the barrel was pulled back slowly, so as to inject cement from the deepest part of the head outward, up to the base of the femoral head [Figure 1]. No cement was injected into the neck of the femur (manual control of cement injection under fluoroscopic guidance) so as not to obstruct the sliding collapse and prevent extrusion of cement into the fracture site. After injecting, the cement gun was quickly removed and the compression screw and barrel plate of DHS was inserted. The guide wire was removed, and a distal fragment was impacted against the proximal one, followed by fixation of the plate to the shaft of the femur. An additional 6.5 mm screw, wherever possible (depending upon diameter of femoral neck), was passed parallel to the DHS, to act as an anti rotation screw, while permitting sliding collapse.8,13 No problem was encountered in drilling for the anti rotation screw. All the anti rotation screws were passed superior to the DHS lag screw, away from the main area of the bone cement, under fluoroscopic control.

All patients were allowed partial weightbearing ambulation under the guidance of a physiotherapist on the second or third postoperative days, and were allowed full weightbearing as soon as possible, depending on the tolerance of the patient. The patients were followed up clinically and radiologically at regular intervals, initially monthly, for the first six months and then every three months, for progress of union, for a minimum period of 12 months. Postoperative radiological assessment included degree of sliding, varus collapse, fracture union, and tip

Figure 1: Clinical photograph (a) Showing assembly of a custommade gun (b) showing different parts of the custommade gun (c) intraoperative fluoroscopic picture showing cement injection in the femoral head with a custommade gun
apex distance (TAD) evaluation. The clinical outcome was rated as per the Salvati and Wilson scoring system at the minimum of one year. Results were graded as excellent (score > 31), good (score 24 – 31), fair (score 16 – 23), and poor (score < 16). Final radiological evaluation included any nonunion, malunion, screw cut-out and implant breakage, AVN of the femoral head, and the extent of sliding collapse.

**RESULTS**

Sixty patients were available for the outcome analysis, as two patients (ASA grade III) died on the third and fifth postoperative days due to medical comorbidities, unrelated to the surgical procedure, and an additional two patients were lost to followup. There were 24 males and 36 females; the average age being 72 years (range, 60 – 94 years). Fall on a level surface was the most common mode of trauma, accounting for 85% (n = 51) of the cases, with high energy road traffic accidents being the next common mode [Table 1]. Prior to injury, 58 (96.7%) patients were ambulatory without any walking aid. The average T score on DEXA scan was 2.8 (-2.5 to -3.4). Average delay to operation from the time of injury was three days (range 2 – 15 days), which was mostly due to delay in reporting to the hospital. Postoperative X-ray examination showed anatomical reduction in 55 cases, and nonanatomical reduction in five cases. One patient had a superficial wound infection, which was managed with antibiotics and one had wound hematoma, which required evacuation. Four patients had postoperative urinary retention, two had urinary tract infection, and five patients had chest infection. These local as well as some systemic complications were appropriately managed. Clinicoradiological consolidation of the fracture was observed in all cases at an average of 13.8 weeks (range 12 – 16 weeks) [Figure 2]. The average followup was 18 months (range 14 – 24 months). Five cases had less than anatomical reduction, as observed in the immediate postoperative period resulting in a few millimeters of shortening, but none of these cases required a shoe raise. The average sliding of the DHS was 3.4 mm. After comparing the postoperative and the last followup radiograph, the degree of sliding was calculated by measuring the incremental change in the length from the tip of the lag screw to the lateral barrel plate. There was no evidence of thermal necrosis in the femoral head, in the form of bone resorption (radiolucent area at implant / cement-bone interface) around the implant or implant loosening. The average TAD was 20.8 mm (range 16-29 mm). No superior migration of the screw was observed in any of our cases, in spite of the fact that TAD was more than 25 mm in 10 of our cases. Full weightbearing was possible in 52 patients by the end of four weeks. There was no incidence of repeat surgical intervention in any of our patients. At the time of final evaluation; the average score for pain, according to the Salvati and Wilson criteria, was 8.63 out of 10. Normal walking was resumed in 46 patients, twelve patients needed a walking aid for long distances, and the remaining two patients required a walking aid even for short distances. The Salvati and Wilson score for the overall hip function was > 31 points in 46 patients and > 20 points in the remaining 14 patients. The functional results in this study were graded as excellent in 76.7% (n=46) of the cases and good in 21.6% (n=13) of the cases. Patients with severe osteoporosis had slightly delayed union time; there was a weak correlation between the DEXA score and time to union (Pearson Correlation). The final functional outcome was not affected by the sex of the patient (T test, P > 0.05), whereas, the final functional status as per the Salvati and Wilson score was better in patients with AO type 31 A2 fracture (T test, P < 0.05), at the one year followup.

**DISCUSSION**

Osteoporotic and comminuted intertrochanteric fractures continue to pose a therapeutic problem. The use of sliding hip screw devices has decreased the frequency of screw penetration through the femoral head, which was common

### Table 1: Demographic profile of patients

| Sex       | Male | Female |
|-----------|------|--------|
| Age Average | 72 years (range, 60 – 94 years). |

| Mode of injury | Fall | RTA |
|----------------|------|-----|
| T score on DEXA scan | Average: -2.8 (2.5 -3.4). |
| Average delay to operation | 3 days (range 2-15 days). |

| Fracture classification | 31-A2.1 | 31-A2.2 | 31-A2.3 | 31-A3.1 | 31-A3.2 | 31-A3.3 |
|-------------------------|---------|---------|---------|---------|---------|---------|
| TAD Average | 20.8 mm (16-29 mm) |

| Union time | Average 13.8 weeks (12-16 weeks) |
|------------|----------------------------------|

| Followup | Average 18 months (14-24 months) |
|----------|----------------------------------|

| Complications | Chest infection | Urinary tract infection | Urinary retention | Local complications | Superficial infection | Wound hematoma |
|---------------|-----------------|-------------------------|--------------------|-------------------|----------------------|-----------------|
|               | 5               | 2                       | 4                  | 1                 | 1                    | 1               |
The use of adjunctive bone cement has been described by Harrington, Muhr et al., and others, where cement has been used to provide a supporting strut in the posteromedial cortical defect. However, the excess amount of cement used may cause delayed / nonunion by slipping into the fracture site and may even prevent the complete sliding of the lag screw, thus converting DHS into a static implant. In a study by Lee et al. using cement augmentation with DHS, with an average amount 13.7 ml of PMMA, the average time to union was 18.1 weeks. The average time of union in our study was 13.86 weeks. Cheng et al. also concluded that, complications in their series of intertrochanteric fractures, were due to inappropriate placement and excessive amount of PMMA cement. The main purpose of the cement was to fill voids in the metaphyseal bone and to improve the holding strength around the metal devices in the osteoporotic bone. Thus, it provided anchorage to the lag screw in the femoral head region to prevent a cut through of the screw. There was no case of nonunion associated with the cement at the fracture site in our study. To avoid cement penetrating into the fracture zone a limited amount of cement (4 − 5 ml) should be introduced into the femoral head using a special injection gun with a long nozzle. Even otherwise the lag screw cut out occurred through the femoral head and not through the neck region. Therefore, it was essentially useful to inject cement into the femoral head area only, as was done in the present study.

Heini et al. studied the role of PMMA cement augmentation in weak osteoporotic bones, to reduce cut out of DHS, in an experimental study on cadaveric femora. They observed that cement augmentation improved the cut out strength of the fixation by about 42%. It was corroborated by the fact that, in the present study, no incidence of implant migration or loosening was observed in spite of established osteoporosis and early weightbearing.

The risk of thermal damage with PMMA use is an important concern. It is postulated that cement filling the intramedullary canal, blocks the normal endosteal blood circulation. Rhinelander et al., however, have reported that there is insignificant loss of intramedullary blood supply with cement, due to the availability of abundant extraosseous blood supply. It has been recognized that bone necrosis is dose dependent, so it is advisable to use a minimum amount of bone cement. In contrast to the study by Lee et al. using cement augmentation with DHS, where the average amount of PMMA used was 13.7 ml, the average amount of cement used in our study was only 4 − 5 ml. The excess amount of cement in the femoral neck, as advocated in that report, had no role, but could raise the issues of bone necrosis or AVN on long term followup. There was no incidence of bone necrosis or AVN hip in our series.

Newer bone cement like calcium phosphate hardens without generating heat and resorbs over time. The compressive strength of calcium phosphate appears to be adequate, but its bending and shear strengths are low. They also have the disadvantage of less stiffness and accelerated
resorption, leading to possible early cement failure before bone healing.\textsuperscript{21} However, the objective of augmentation with bone cement is to provide immediate strength to aid lag screw anchorage and early weightbearing.

One of the major concerns during cement injection is the penetration of the cement into the joint. It is therefore important that the guide wire reach only the subchondral bone and not penetrate into the joint. However, as in our technique, the cement was injected with a guide wire in situ, even an erroneous intraarticular penetration of the guide wire is unlikely to allow the cement to enter into the joint, because the hole created by the penetration of the wire will be occupied by the wire till the cement sets in. It is corroborated by the fact that there was no instance of cement penetration in the present study. Subsequent introduction of the DHS screw is likely to provide some pressurization as well. As a result, the cement will form a mantle around the implant, thereby providing strength where it is needed most. In contrast, the technique reported by Dall’Oca \textit{et al}.\textsuperscript{22} is likely to provide strength primarily in the subchondral area, at the tip of the DHS screw, instead of its superior surface. Moreover, as the cement was injected after the final placement of DHS in the proximal femur in their study, there was also the possibility of cement penetration into the joint, in case of inadvertent penetration by the guide wire.

Tip apex distance predicts the lag screw position within the femoral head and is believed to be an independent predictor of lag screw cut out. In our series no superior migration or cut out of lag screw was observed despite the TAD being more than 25 mm in 10 of our patients. The tip apex distance is the sum of the distances from the tip of the lag screw to the apex of femoral head on both AP and lateral radiographic views. Peripheral placement of the lag screw tends to increase the TAD [1]. Higher tip apex distance in some of our cases was primarily because of slightly inferior placement of the DHS screw, to accommodate the additional anti rotation lag screw superiorly. Guven \textit{et al}. has reported that although peripheral placement of the screw in the femoral head increases tip-apex distance, the posterior and inferior locations of the lag screw may help to support the posteromedial cortical and calcar in unstable intertrochanteric fractures, and reduce the risk of cut-out failure.\textsuperscript{23} The mean sliding in our study was an average of 3.4 mm, which was significantly lower than the previous studies using DHS alone.\textsuperscript{24,26} Cement augmentation of DHS results in the firm anchorage of the implant in the femoral head, thereby, not allowing backward migration of the screw as a whole, in the osteoporotic bone. Moreover, this could also be explained by the fact that all the cases in the present study had either an intact lateral wall or it was reconstructed to prevent excessive medial migration of the distal fragment. Cement augmentation added another step to the surgical procedure and prolonged our operating time by approximately four to five minutes. Perioperative bleeding is in part related to the operating time, but if proper hemostasis is achieved, there is hardly any extra blood loss during surgery, on account of cement augmentation.

Polymethylmethacrylate being inert and non biodegradable, is likely to persist within the femoral head forever. Long term persistence of PMMA may influence the rate of bone remodeling by affecting bone metabolism and the trabeculae may be weakened by change in the mechanical environment.\textsuperscript{27} Thus, it is advocated that PMMA augmentation should only be used in elderly patients with osteoporosis and limited life expectancy, till long term results are available.

The results of our study do indicate that PMMA-augmented hip screw is a useful option in trochanteric fractures, in elderly osteoporotic patients, although the study has a limitation of the number of patients (n = 60) and absence of a control group. Larger control studies with long term followup may be required before advocating it for a wider application.

**Conclusion**

Polymethylmethacrylate augmentation of DHS with a limited amount of bone cement is likely to reduce the incidence of complications of fixation like implant failure, in spite of early weightbearing, in elderly osteoporotic patients with trochanteric fractures.

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