Treatment of neglected femoral neck fractures using the modified dynamic hip screw with autogenous bone and bone morphogenetic protein-2 composite materials grafting

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ABSTRACT

Background: The neglected femoral neck fracture is one where there has been a delay of more than 30 days to seek medical help from the time of the original injury. Salvage procedures, such as osteotomy and other treatment options such as vascularized and nonvascularized bone grafts have high failure rates and arthroplasty procedures are not ideal, given the patient’s young age and higher levels of activity. We designed a hollow bone graft dynamic hip screw (Hb-DHS) (modified DHS, Hb-DHS) for use in neglected femoral neck fractures. This study evaluates the efficacy and safety of the modified dynamic hip screw (DHS) with autogenous bone and bone morphogenetic protein 2 (BMP-2) composite materials grafting for the treatment of the neglected femoral neck fractures.

Materials and Methods: A prospective study was carried out in twenty patients of neglected femoral neck fractures treated with the modified DHS with autogenous bone and BMP-2 composite materials grafting between July 2007 and February 2010. There were 14 men and 6 women with a mean age of 29.6 years (range 19–42 years). The mean time from injury to surgery was 9.7 weeks (range 6–16 weeks). The operation time, intraoperative blood loss, fracture healing time, Harris scoring for hip function and complications were recorded to evaluate treatment effects.

Results: The mean operation time was 75.8 min (range 55–100 min) with mean intraoperative blood loss volume of 105 mL (range 70–220 mL). The mean time to union was 17 weeks (range 12–24 weeks). One patient did not achieve union, and two patients had avascular necrosis of the femoral head. This patient with nonunion underwent intertrochanteric osteotomy. In patients with avascular necrosis one required total hip arthroplasty, the other did not require intervention at the last followup. A total of 14 patients (70%) had excellent results, 2 (10%) had good, 1 (5%) had moderate and 3 (15%) had poor results.

Conclusion: The modified DHS with autogenous bone and BMP-2 composite materials grafting for the treatment of neglected femoral neck fractures was effective and had less complications.

Key words: Bone graft, dynamic hip screw, femoral neck fractures, fixation, bone morphogenic protein

MeSH terms: Femur, femoral neck fractures, autograft, bone screws

INTRODUCTION

The neglected femoral neck fracture is one where there has been a delay of more than 30 days to seek medical help from the time of the original injury.1 This complication may lead to collapse of the femoral head and osteoarthritis. Salvage procedures, such as osteotomy and other treatment options such as vascularized and nonvascularized bone grafts have high failure rates and arthroplasty procedures are not ideal, given the patient’s young age and higher levels of activity.2,3 We designed a hollow bone graft dynamic hip screw (Hb-DHS) (modified DHS, Hb-DHS) for use in neglected femoral neck fractures. It was shown in previous study that the Hb-DHS promotes femoral neck bone union, stimulates trabecular bone formation, increases bone mineral
density with reliable internal fixation in an experimental study.\textsuperscript{4} Thus nonunion and femoral head avascular necrosis could be greatly decreased. The purpose of this study was to evaluate the efficacy and safety of the Hb-DHS with autogenous bone and bone morphogenetic protein 2 (BMP-2) composite materials grafting for the treatment of the neglected femoral neck fractures in young adults.

**MATERIALS AND METHODS**

**Implant details**

We have designed a Hb-DHS, for which we have obtained a patent (patent number: 201110146729.6). This device is made of titanium alloy and is divided into a head, middle and end sections. The head section, which is threaded and has some holes in it, is used to fix the femoral head. Autogenous bone and BMP-2 composite materials are inserted into the middle section, which has a flabellum-like-cavity. The diameter of the head and middle sections are 13 mm. The end section is inserted into a 135° angle plate [Figure 1].

20 patients of neglected femoral neck fractures were treated with the modified DHS with autogenous bone and BMP-2 composite materials grafting from July 2007 to February 2010. There were 14 men and 6 women with a mean age of 29.6 years (range 19–42 years). 11 patients had right side involvement and 9 patients had a left side involvement. The mode of trauma included motor vehicle accident (n = 11), fall from height (n = 9). The mean time from injury to surgery was 9.7 weeks (range 6–16 weeks). Sandhu’s classification was used in the classification of the fractures.\textsuperscript{5} There were 11 patients of stage I and 9 in stage II [Table 1]. The study was approved by the ethics committee. Anteroposterior and lateral radiographs of the hip joint were taken in all patients and computerized tomography examinations were obtained if necessary.

**Operative procedure**

All the patients were operated using fracture table in supine position under general or spinal anesthesia through anterolateral Watson–Jones approach. After fracture reduction under direct vision, the capsular incision was not closed. Satisfactory reduction (<5 mm of displacement and/or <10° of angulation in any plane) was confirmed by fluoroscopy before internal fixation. A 2.0 mm guide wire using an appropriate angle guide, (usually 125°–135°), was introduced at the level of the lesser trochanter. It is important that the wire should not be positioned too anteriorly or posteriorly from its entry portal and should be central in the femoral head on the anteroposterior and the lateral X-rays into the femoral head. A triple reamer type device reams a path for the screw into the femoral head and also the lateral cortex for the plate barrel junction. The autogenous iliac-crest graft and BMP-2 (Hangzhou Jiuyuan Gene Engineering Co., Ltd., Hangzhou, China) composite materials were filled into the flabellum-like-cavity of a Hb-DHS [Figure 2], and fixation was achieved with Hb-DHS. Addition of a derotational screw placed in the cranial part of the femoral neck superior to the Hb-DHS in all the patients can improve the rotational stability of the construct.

**Postoperative treatment and followup assessment**

Patients were mobilized and instructed to use toe-touch weight-bearing with crutches or a walker for 12 weeks. Patients progressed to full weight-bearing when they had the strength and the balance to do so. They were instructed to
wean off from crutch support when they were able to walk without a substantial limp. They were called for followup at 6 months, 1 year and 2 years.

Clinically they were assessed for pain, limitations of movements and limb length discrepancy. Radiologically the degree of union, loss of fracture alignment, trabecular integrity at the fracture site, late segmental collapse and the presence of avascular necrosis were observed. Avascular necrosis was assessed according to criteria of Ficat. Patients were evaluated by the Harris hip scoring system.

**RESULTS**

The mean followup period was 27.7 months (range 24–32 months). There were no intraoperative complications related to this technique. The mean operation time was 75.8 minutes (range 55-100 minutes) with mean intraoperative blood loss volume of 105 mL (range 70–220 mL). The direct radiography of all patients showed that the position of the implants was good and the screw did not pull out of the femoral head. In postoperative radiographs the quality of femoral neck reduction was assessed by Haidukewych et al. Fracture reduction was classified as excellent (<2 mm of displacement and <5° of angulation in any plane), good (2–5 mm of displacement and/or 5°–10° of angulation), fair (>5–10 mm of displacement and/or >10°–20° of angulation), or poor (>10 mm of displacement and/or >20° of angulation, or any varus). Postoperative success of implant placement was excellent in fifteen cases, good in three and fair in two cases.

The mean time to union was 17 weeks (range 12–24 weeks) [Figures 3A-D and 4]. One patient (stage II) did not achieve union and two patients (one was stage I and other was stage II) had avascular necrosis of the femoral head during their followup. The patient with nonunion was taken up for intertrochanteric osteotomy in the 12th postoperative month. This patient was considered as having a poor outcome. The patient with avascular necrosis stage II required total hip replacement while the other did not require any intervention till the last followup. These were considered as poor outcome [Table 1].

According to the Harris hip score, 14 patients (70%) had excellent results, 2 (10%) had good, 1 (5%) had moderate and 3 (15%) had poor results [Table 1].

**DISCUSSION**

Salvaging the femoral head for young adults (age <60 years) with neglected femoral neck fracture is challenging. In geriatric patients (age ≥60 years), hemiarthroplasty or total hip arthroplasty often results in a satisfactory outcome. In younger patients, joint replacements are less ideal because of higher functional demands. The beneficial effects of valgus osteotomy, fibular grafting with internal fixation, vascularized bone grafting and muscle pedicle bone grafting

Table 1: Clinical details of patients

| Sex | Age (year) | Sandhu’s classification | Time from injury to surgery (weeks) | Time to heal (weeks) | Followup (months) | Harris hip score | Complication |
|-----|------------|-------------------------|-----------------------------------|---------------------|------------------|----------------|--------------|
| Male | 22         | Stage I                 | 6                                 | 16                  | 32               | Excellent       | /            |
| Male | 34         | Stage II                | 10                                | 18                  | 27               | Excellent       | /            |
| Male | 30         | Stage I                 | 7                                 | 15                  | 24               | Excellent       | /            |
| Female | 23        | Stage II                | 13                                | 24                  | Poor             | Nonunion       |             |
| Female | 22        | Stage II                | 12                                | 25                  | Excellent       | /            |
| Male | 19         | Stage I                 | 11                                | 17                  | 32               | Good           | /            |
| Male | 26         | Stage I                 | 6                                 | 14                  | 27               | Excellent       | /            |
| Male | 31         | Stage I                 | 9                                 | 16                  | 30               | Excellent       | /            |
| Male | 30         | Stage II                | 9                                 | 28                  | Poor             | Avascular necrosis |         |
| Female | 37        | Stage II                | 15                                | 26                  | Excellent       | /            |
| Male | 32         | Stage I                 | 8                                 | 20                  | 30               | Moderate        | /            |
| Female | 39        | Stage I                 | 7                                 | 24                  | Excellent       | /            |
| Male | 32         | Stage II                | 12                                | 28                  | Excellent       | /            |
| Male | 28         | Stage II                | 16                                | 31                  | Excellent       | /            |
| Female | 42        | Stage I                 | 8                                 | 28                  | Good            | /            |
| Male | 35         | Stage II                | 12                                | 24                  | Excellent       | /            |
| Male | 29         | Stage II                | 9                                 | 25                  | Excellent       | /            |
| Male | 35         | Stage I                 | 8                                 | 32                  | Poor             | Avascular necrosis |         |
| Female | 25        | Stage I                 | 7                                 | 27                  | Excellent       | /            |
| Male | 21         | Stage I                 | 6                                 | 30                  | Excellent       | /            |
in enhancing and promoting union of neglected femoral neck fractures has been documented in the literature.\textsuperscript{1,3,11} However, valgus osteotomy has two important problems. Shortening, limp and a decreased range of movement are common, probably because of increased pressures on the femoral head leading to degenerative disease or osteonecrosis. Second, there is potential risk of nonunion at the osteotomy site. Fibular grafting with internal fixation, vascularized bone grafting and muscle pedicle bone grafting have donor site complications plus these techniques are highly technical and require microsurgical facilities and experience.\textsuperscript{12}

In consideration of the above, our research group designed a new device in collaboration with Double Engine Medical Material Co. Ltd., (Xiamen, China) to produce it. The device is an improved DHS. The head section of the Hb-DHS is threaded, has some holes and is used to fix the femoral head, possibly with less capsular and intramedullary pressure than there is with the traditional DHS. The middle section of the Hb-DHS has a flabellum-like-cavity into which autogenous bone and BMP-2 composite materials are inserted to decrease nonunion and chances of femoral head AVN and also to promote creeping substitution of bone and to some extent, augment bone trabecular volume and bone mineral density. Moreover, the diameter of the head and middle sections are 13 mm, which is significantly greater than for the traditional DHS and therefore provides reliable internal fixation. The end section of the Hb-DHS inserts into a 135° angle plate. In this study, the method involved the use of autogenous iliac-crest graft and BMP-2.

Table 2: Neglected femoral neck fractures in young adults - a comparison of the literatures

| Authors       | Year | Number of patients | Method                                      | Nonunion, % | Avascular necrosis, % | Good functional outcome, % |
|---------------|------|--------------------|---------------------------------------------|-------------|-----------------------|---------------------------|
| Kalra et al.\textsuperscript{13} | 2001 | 20                 | Osteotomy                                   | 15          | 10                    | 75                        |
| Huang\textsuperscript{14}         | 1986 | 16                 | Osteotomy                                   | 0           | 25                    | 81                        |
| Nagi et al.\textsuperscript{12}   | 1998 | 40                 | Fibular grafting with internal fixation      | 5           | 12                    | 70                        |
| Baks\textsuperscript{15}          | 1986 | 56                 | Vascularized bone grafting                  | 11          | 67                    | 82                        |
| This study    | 2013 | 20                 | Modified dynamic hip screw                 | 5           | 10                    | 80                        |
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In summary, our study demonstrates that the modified DHS with autogenous bone and BMP-2 composite materials grafting show a low incidence of nonunion and femoral head avascular necrosis complication, and is suitable for the treatment of the neglected femoral neck fractures in young adults.

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