Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/jor

Original Article

Total hip arthroplasty using S-ROM prosthesis in elder patients with type C and B bone

Zhong-Shou Zhao, Jun-Ying Sun*

Department of Orthopaedic Surgery, The First Affiliated Hospital of Soochow University, Suzhou, Jiangsu Province 215006, PR China

ARTICLE INFO

Article history:

Received 18 January 2012

Accepted 1 April 2013

Available online 16 May 2013

Keywords:

Total hip arthroplasty

S-ROM

Elder patients

Type C and B bone

ABSTRACT

Objective: The purpose of this study was to evaluate the clinical and radiological results using S-ROM prosthesis in patients with type C and B femoral bone requiring primary total hip arthroplasty (THA) for multiple reasons.

Methods: Sixteen hips were followed up for a mean of 38 months (range, 26–48), with a mean age at surgery of 72 years (range, 65–75).

Results: The average Harris hip score improved from 52.2 points to 88.5 points. All femoral stems showed stable fixation. Neither osteolysis around the femoral stem nor subsidence of the femoral stem were found at the final follow-up.

Conclusion: For the patients with poor bone quality, total hip arthroplasty with the use of the proximal modular femoral stem yielded good short-to-mid-term results with respect to the clinical and radiological criteria.

Copyright © 2013, Professor P K Surendran Memorial Education Foundation. Publishing Services by Reed Elsevier India Pvt. Ltd. All rights reserved.

1. Introduction

When cementless femoral prostheses first were introduced, it was hoped that they would provide long-term survivorship for younger and active patients with normal bone structure and normal healing capacity. Along with biomechanically optimized implant designs and bioactive coatings for enhanced bone ingrowth, the indications have gradually been expanded to include even THAs in elderly patients with impaired bone quality and limited healing capacity. Elder patients tended to have the comorbidity diabetes which was the main cause leading to osteoporosis, also the osteopenic symptoms could easily be seen in female patients after the menopause. As a result, the elder patients with decreased bone stock typically have a greater proportion of Dorr Type B and C bone compared to younger patients. Dorr Type C and B bone exhibits osteoporotic

cortical degradation, as well as intramedullary canal widening,¹ disproportionately widening the diaphysis. The mismatch between the metaphysis and the diaphysis can lead to intraoperative iatrogenic fractures and inability for surgeons to get optimal fit and fill by conventional cementless stems.

Thus far, various design philosophies have evolved in an attempt to increase the reproducibility of bone ingrowth in all THA cases. An alternate method that was developed to obtain canal fit and fill with varying femoral size and geometry was implant modularity. The S-ROM femoral implant (DePuy Orthopaedics Inc., Warsaw, Ind) was one of the earliest modular designs. Based on separate stem and hollow proximal sleeve components, this implant which can be used as the off-the-shelf custom prosthesis enabled the surgeon to combine intraoperatively a metaphyseal-filling and diaphyseal-filling implant.^{2–5}

* Corresponding author. Tel.: +86 18862315956.

E-mail address: kangleyuanjiashu@163.com (J.-Y. Sun).

To our acknowledgment, there were many reports with mid-to-long-term follow-up depicting the excellent clinical results,^{2,5} but rare studies were made for elder patients with bone stock deficiency undergoing primary THA using the S-ROM stem. The purpose of this study was to evaluate retrospectively the clinical and radiographic results of the S-ROM modular femoral stem in primary THA applied to this special group.

2. Materials and methods

A total of 89 consecutive primary cementless THAs using the S-ROM femoral component were performed in 82 patients in our institution between July 2008 and March 2010. All the operations were executed by a single surgeon (Sun). The patients' data were recorded prospectively and analyzed retrospectively. In the beginning of this study, we set two limits to select the qualified patients. In the age-related step, we selected the patients older than 65 years, 22 patients (24 hips) remained. According to the method by Dorr¹ (Fig. 1), 8 patients (8 hips) were classified as type A bone, 8 patients (10 hips) were classified as type B bone, 6 patients (6 hips) were classified as type C bone. The patients with type A bone were removed, the

Fig. 1 – The canal to calcar isthmus ratio (CC ratio) was calculated on the preoperative AP view. Mid-lesser trochanteric line, also reference line was marked A. The line 3 cm below the reference line was marked B and the line 10 cm below the reference line was marked C. The CC ratio (x/y) was 100% and the bone type was type C bone.

remaining 14 patients (16 hips) were qualified to participate in this follow-up research. All of these enrolled patients can be contacted during the follow-up period by outpatient routine, by E-mail correspondence or by telephone interviews. The complete clinical and radiographic data about these 14 patients formed the basis of this study.

The patients were followed retrospectively for a mean of 38 months (range, 26–48 months). There were 10 women and 4 men. The minimum patient age was 65 years, the mean age of the patients at the time of surgery was 72 years (range, 65–75 years). The initial diagnosis was developmental dysplasia in 9 hips (56%), degenerative osteoarthritis in 7 hips (44%). The THA involved the left hip in 10 cases and the right hip in 6 cases.

The S-ROM femoral prosthesis was implanted in all cases using the modified Hardinge anterolateral approach to the hip. The femoral diaphysis was reamed progressively to the minor diameter of the stem. The metaphysis was reamed with conical reamers until cortical bone was reached, and the calcar was milled with a side-cut drill. The sleeve was implanted, and the stem subsequently was inserted through the sleeve in the appropriate anteversion. In our series, much attention was paid when the stems were inserted and no iatrogenic fractures happened as a result.

Though different levels of osteoporosis existing in our series, no routine anti-osteoporosis drugs were used. Antibiotic prophylaxis (Rocephin) was administered preoperatively and for 48 h postoperatively. For those patients with much blood loss in operation, hemostatic medicine (Etamsylate, 0.5 g twice a day) was administered immediately after operation.

The size of metal-backed acetabular cup used in operation varied from 50 mm to 56 mm. The articular surface used herein was metal–metal articulation in 11 cases and ceramic–ceramic articulation in 5 cases. The range of femoral head size used in our series was from 36 mm to 45 mm. Ambulation and physical therapy in bed were started on the third to fifth postoperative day. According to the individual recovery condition of the abductor strength, fully weight bearing was permitted seven to ten days after operation.

All patients were followed retrospectively with Harris hip scores and radiographs. Patients were questioned specifically regarding thigh pain and the pain level was evaluated according to VAS. Radiographic views included an anteroposterior hip and pelvis and true lateral of the hip. Preoperative radiographs were assessed to determine the femoral bone quality according to Dorr's criteria.¹ Radiographic analysis was carried out according to the recommendations of Johnston et al. Besides, the distance between the inter-teardrop line and the mid-lesser trochanter line was measured on the AP view of hips during each interview. Whether there was stem subsidence or not was then judged through the observation of the changes of the distance. Implant stability was classified as bony ingrown, fibrous stable, or unstable according to the classification of Engh et al. In compliance with the method by Martell, the angle between the femoral diaphysis axis and the prosthesis axis in the coronal plane was measured. When the angle was 5° or more, varus or valgus was determined. The locations of osteolysis and radiolucent lines were analyzed in accordance with the classification system proposed by Gruen.

3. Results

No patients were lost to follow-up, and none had died. No S-ROM stems have been revised. 3 patients had 3-point thigh pain according to the VAS during the first 3 months after operation, and two cases of these had a radiolucent line around the femoral stem. But the symptoms disappeared after 1-year follow-up, and the radiolucent lines around the stem did not progress.

The passive motion degrees on average before the operation of the 16 hips were flexion 92°, adduction 10°, abduction 15°, external rotation 20° and internal rotation 9°. In comparison, postoperative motion degrees increased to flexion 110°, adduction 28°, abduction 35°, external rotation 30° and internal rotation 20°.

The preoperative Harris hip score was 52.2 points on average. At the final follow-up, the mean Harris hip score was 88.5 points. Of all the cases, 12 cases were assessed as 'Excellent', 2 cases were 'Good', 2 cases were 'Fair' and none of the cases were 'Poor'. Overall, clinical findings of more than 'Good' were presented at the final follow-up for 14 cases (87%).

The overall 16 cases showed stable fixation of the acetabulum and the femoral stem.

4. Radiographic findings

Based on the assessment of the preoperative radiographs, 16 femurs in our series were identified as type C or type B according to Dorr's criteria.¹ On review of latest radiographs, no subsidence of the femoral stems in all hips was found.

Endosteal spot welds around the distal part of the sleeve was identified in 11 femurs (Fig. 2), which we defined as bony stable. The remaining 5 hips without apparent bone ingrowth hints were defined as fibrous stable. Particle shedding and

osteolysis were not seen in all Gruen zones. All the femora did have a degree of bone atrophy located entirely within Gruen zone I and Gruen zone VII. According to the radiographs, slight varus of the stem happened in 2 hips in the 1-year follow-up after the operation while the varus did not progress in subsequent interviews (Fig. 3). Pedestal formations below the distal end of these 2 stems were noted. There were no cases of trochanteric fractures, and there was no distal osteolysis evident radiographically.

5. Discussion

There have been a number of historical reports indicating other designs of stems can be successfully implanted in older patients.^{6,7} Thus, we conclude that osseointegration of uncemented components is based on new bone ingrowth and ongrowth which is inhibited by excessive micromotion, and high initial stability is one of the key factors for rapid osseointegration of an implant in spite of different design philosophies. The design philosophy of the S-ROM stem is to achieve proximal ingrowth and loading to create a physiologic pattern of bone stresses that reduces stress-shielding. Although the stem is not porous-coated distally, it is designed to maximize the intramedullary fit proximally and distally to minimize micromotion and enhance bone ingrowth. The proximal ingrowth is provided by the porous-coated or hydroxyapatite-coated proximal sleeve which has the ZTT steps to convert hoop stresses to compressive axial stresses. The sleeve connects to the stem by a Morse taper which in vivo is loaded in compression to minimize micromotion and to provide rotational stability for up to 3 times a patient's body weight.⁸ In addition, the S-ROM stems have distal flutes that increase the distal root diameter by 1.25 mm to enhance the rotational stability. Therefore, the main item in our study is to observe that once initial stability was

Fig. 2 – Radiograph of a 75-year-old woman who had had primary total hip arthroplasty of the right hip. A, A preoperative AP view and development dysplasia of the right hip was noted. B, Seven days after total hip arthroplasty using the S-ROM prosthesis, a routine AP view of the hip was taken. C, 2 years postoperatively, the trabecular line (spot welds) between the endosteal surface and the distal end of the sleeve was noted.

Fig. 3 – A, The preoperative radiograph of a 69-year-old woman. B, Immediate radiograph after the operation, excellent press-fit of the stem in the host bone was well presented. C, Slight varus of the stem was noted one year after the operation, the white arrow pointed at where the pedestal formation happened.

achieved using the S-ROM stem, whether (1) the bone quality in elder patients affects long-term stability and bone ingrowth, (2) the hip function and pain scores can also get a great improvement in this subset of general population.

Some defects are obvious in our study and are listed as follows. First, radiographic analysis is inferior to roentgen stereophotogrammetric and dual-energy X-ray analysis in determining bone mass, remodeling, and component migration. However, Engh et al have reported successful systematic methods of evaluating bone remodeling on radiography and by histologic examination. Thus, a thorough assessment of bone remodeling from radiographs, though without accuracy of advanced imaging, is dependable. Second, HHS score is intuitively based on patient report and is subject to patient reporting bias; however, any bias effect would be no greater in our study than in other studies using the widely acknowledged hip pain and function scoring systems. Third, long-term follow-up is necessary to judge the durability of the implant. However, some literature about the S-ROM stem is of mid-term follow-up⁵ which is sufficient to evaluate and predict the stem stability through reviewing the remodeling around the prosthesis. Longer follow-up in our study is under way. Lastly, we did not measure for inter- and intraobserver variability of radiographic measurement but instead agreed on findings through consensus.

Asseptic loosening remains a main concern about the long-term survivorship of the cementless stem in diminished bone which adversely affects the ingrowth/outgrowth of the implant. Since the diminished cellular and structural characteristics exist in osteoporotic bone, bone stock preservation in operation is extremely important to prevent aseptic loosening and subsequent migration, subsidence or osteolysis. In our series, no femoral component was revised for aseptic loosening, which we thought mostly attributable to the equipment specially mated with the S-ROM stem in preparing the femoral canal. The “broach-less” system used

in S-ROM arthroplasty is less traumatic when dealing with the compromised bone stock. The study of Christie MJ analyzed the clinical and radiographic results of 159 patients with minimum follow-up of 4 years using S-ROM stem in primary THA.⁵ It also involved Door type C femur (13 patients, 8%) and only one femoral component was revised for aseptic loosening. Similarly, another research exhibited satisfying results using S-ROM stem in patients with deficient bone stock though the mean age of the patients was 42.6 years.⁹ In the total 31 patients, one patient accepted revision surgery at 6 years for distal osteolysis caused by aseptic loosening.

In a review of the literature, the fretting and corrosion in the taper junctions have been always the concern of the orthopaedic community.^{10,11} Numerous metallic particles possibly would be developed as a result of the micromotion between the modular parts and were transferred to the distal end of the implant through effective joint space. Furthermore, the osteolysis resulting from these debris can be disastrous in prospect. Osteolytic lesions were observed in no hips in our series. Many factors influenced the low rate of osteolysis in our series and we summarized the possible reasons as below. Firstly, the femur metaphysis was prepared independent from the diaphysis, which promised the close contact of the sleeve with the femur. With further intercalation of the sleeve-stem taper junction after load-bearing, the micromotion was effectively avoided. Secondly, we selected the elder patients as the target group. As the subset of the general population, they require less activity than the young people and which can also decrease the fretting. Furthermore, this point concurs with the study by D’Antonio¹² who reported that significantly higher rates of osteolysis were found to be associated with an age of less than fifty years ($p = 0.009$).

The average Harris hip score in our series was 85.5 points, with a good or excellent result in 87% (14) of 16 hips. The clinical results were similar to those of other series with

intermediate-term and long-term follow-up after insertion of femoral components of other designs. In a study of 1994 patients (2321 hips) who were followed for a minimum follow-up of 2 years after insertion of a proximally porous-coated straight stem of diverse types, Meding et al⁷ reported that the average Harris hip score of Dorr Type C group was 94.7 points and found no differences among Classes A, B, and C hips at final follow-up. Berend et al¹³ evaluated 49 hips in patients 75 years and older with an uncemented double-tapered implant at an average 5 years postoperatively and found a mean HHS of 84, an increase of 39 from preoperative HHS scores. We truly agree on that, it is impossible to directly compare functional results of patient cohorts that were not matched; however, the functional results in our series with use of modular femoral implants do not appear to be significantly different from those of other series in which a variety of femoral implants were used.

Remodeling of the femur was evident to some degree in all hips in this study. These changes include the endosteal spot welds, distal pedestal formation and bone atrophy proximal to the sleeve. In history, these findings have been noted in some report concerning the S-ROM stem as well.⁵ It appears as though bony growth into the porous coating, proximal bone atrophy and pedestal formation, which suggest distal stress transfer and proximal fixation, are benign radiographic findings for this titanium-based alloy stem.

Proximal femoral bone atrophy and thigh pain have been always the concerns with use of cylindrical stems,^{14,15} especially in patients with poor bone quality and when large diameter stems are implanted. In operation, the distal diameter of S-ROM stem has to be selected as large as possible to obtain anchorage within endosteal bone for immediate stability. However, in our series, only 3 patients complained of thigh pain after operation and the symptoms disappeared 3 months later. It seems that the hollow cylindrical stem with a coronal slot greatly decreases the stiffness difference between the implant and the host bone which is the main reason leading to thigh pain. According to radiographic findings, bone atrophy zones were confined to Gruen I and Gruen VII, which indicated bone ingrowth into the proximal porous-coated sleeve promising the long-term survival of the stem.

The present study shows that S-ROM stem functions satisfactorily even in elderly patients with less optimal bone quality according to the short term follow-up results. Even though remodeling of the proximal femur is common among the patients in this series, initial fixation and long-term durability is reliable.

Conflicts of interest

All authors have none to declare.

REFERENCES

1. Dorr LD, Faugere MC, Mackel AM, Gruen TA, Bogner B, Malluche HH. Structural and cellular assessment of bone quality of proximal femur. *Bone*. 1993;14:231.
2. Chandler HP, Ayres DK, Tan RC, et al. Revision total hip replacement using the S-ROM femoral component. *Clin Orthop Relat Res*. 1995;319:130.
3. Cameron HU. Modularity in primary total hip arthroplasty. *J Arthroplasty*. 1996;11:332. discussion 337.
4. Smith JA, Dunn HK, Manaster BJ. Cementless femoral revision arthroplasty. *J Arthroplasty*. 1997;12:194.
5. Christie MJ, DeBoer DK, Trick LW, et al. Primary total hip arthroplasty with use of the modular S-ROM prosthesis. *J Bone Joint Surg Am*. 1999;81:1707.
6. Kelly SJ, Robbins CE, Bierbaum BE, Bono JV, Ward DM. Use of a hydroxyapatite-coated stem in patients with Dorr Type C femoral bone. *Clin Orthop Relat Res*. 2007;465:112.
7. Meding JB, Galley MR, Ritter MA. High survival of uncemented proximally porous-coated titanium alloy femoral stems in osteoporotic bone. *Clin Orthop Relat Res*. 2010;468:441.
8. Bobyn JD, Tanzer M, Krygier JJ, Dujovne AR, Brooks CE. Concerns with modularity in total hip arthroplasty. *Clin Orthop*. 1994;298:27.
9. Cameron HU, Lee OB, Chou H. Total hip arthroplasty in patients with deficient bone stock and small femoral canals. *J Arthroplasty*. 2003;18:35.
10. Fraitzl C, Buly R, Castellani L, Moya L. Corrosion at the sleeve-stem interface of a modular titanium alloy femoral component. *J Bone Joint Surg Br*. 2010;92(suppl 4):514.
11. Goldberg JR, Gilbert JL, Jacobs JJ, Bauer TW, Paprosky W, Leurgans SA. Multicenter retrieval study of the taper interfaces of modular hip prosthesis. *Clin Orthop Relat Res*. 2002;401:149.
12. D'Antonio JA, Capello WN, Manley MT. Remodeling of bone around hydroxyapatite-coated femoral stems. *J Bone Joint Surg Am*. 1996;78-A:1226.
13. Berend KR, Lombardi AV, Mallory TH, Dodds KL, Adams JB. Cementless double-tapered total hip arthroplasty in patients 75 years of age and older. *J Arthroplasty*. 2004;19:288.
14. Campbell ACL, Rorabeck CH, Bourne RB, et al. Thigh pain after cementless hip arthroplasty: annoyance or ill omen? *J Bone Joint Surg Br*. 1992;74:63.
15. Barrack RL, Jasty M, Bragdon C, et al. Thigh pain despite bone ingrowth into uncemented femoral stems. *J Bone Joint Surg Br*. 1992;74:507.