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Management of uncontained bone defect in revision total knee arthroplasty with double modular metal augments: a report of 3 cases with a review of literature

Aree Tanavalee*
Pongsak Yuktanandana* Chaithavat Ngarmukos*

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Problems : *Surgeons always have options to reconstruct uncontained bone defects in revision total knee arthroplasty. Structural allograft is known to limit weight-bearing ambulation and cause further complications. An expensive custom-made prosthesis, however, offers less flexibility regarding soft tissue balancing. Whereas, a thick modular augmentation which provides easy surgical technique could be beneficial, given that adequate varieties of modular augments are available.*

Objective : *Alternative to the methods, we reported results of using a modified technique with double polymethylmethacrylate (PMMA), a precoated modular metal augments for management of severe uncontained bone defects.*

Design : *Retrospective descriptive study*

Materials and Methods : *Double polymethylmethacrylate (PMMA) precoated modular metal augments was employed in the management of severe uncontained bone defects in 3 selected cases of elderly women, with their mean follow-up period of 11 months.*

* Department of Orthopedics, Faculty of Medicine, Chulalongkorn University

Results : *All the patients had satisfied clinical results and radiographic stable prostheses.*

Conclusions : *The technique was simple and reproducible with early predictable results. However, the available double augments should have the exact thickness that matches the height of the prepared bone defect. In a situation that has limited types of supply of modular augmentation for revision knee surgery, we recommend the technique for selected patients, who are undergoing a revision of knee arthroplasty, and in whom an allograft, or a custom-made prosthesis is not favorable. In addition, the technique needs further follow-up study to evaluate the longevity of the fixation between the two augments.*

Key words : *Bone defects, Revision, Total knee arthroplasty, Metal augment.*

Reprint requests: Tanavalee A, Department of Orthopedics, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand.

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อารี ตนาวลี, พงศ์ศักดิ์ ยุกตะนันทน์, ชายธวัช งามอุโฆษ. การแก้ไขการสูญเสียเนื้อกระดูกชนิดไม่มีขอบกระดูกขณะทำผ่าตัดเปลี่ยนข้อเข่าเทียมชุดใหม่ โดยใช้โลหะหนุน 2 ชั้น : รายงานผู้ป่วย 3 รายและทบทวนวรรณกรรม. จุฬาลงกรณ์เวชสาร 2545 ก.พ; 46(2): 143 – 53

ปัญหา : *เนื่องจากการแก้ไขปัญหาการขาดเนื้อกระดูกจากการที่เกิดการหลุดหลวมของข้อเข่าเทียม โดยเฉพาะการขาดเนื้อกระดูกอย่างมากชนิด uncontained defect มีความยุ่งยาก และแพทย์มีทางเลือกในการรักษาน้อย ในการทำผ่าตัดเปลี่ยน ข้อเข่าเทียมชุดใหม่ หากแพทย์ต้องแก้ไขปัญหาการขาดเนื้อกระดูกชนิดนี้ร่วมด้วย วิธีการที่นิยมใช้คือคือการนำกระดูก allograft มาเสริม ซึ่งอาจเกิดข้อแทรกซ้อนได้สูง โดยเฉพาะการติดเชื้อ หรือใช้ข้อเทียมชนิดทำขึ้นเฉพาะตัวผู้ป่วย ซึ่งมีข้อจำกัดมากเมื่อทำขึ้นมาไม่พอดีกับข้อเข่าที่จะทำการผ่าตัด ส่วนการใช้ชิ้นโลหะเป็นตัวหนุนก็มักมีข้อจำกัดจากความสูงของตัวหนุนเองมีไม่เพียงพอ*

วัตถุประสงค์ : *คณะผู้วิจัยได้ประยุกต์การใช้ชิ้นโลหะเป็นตัวหนุน และรายงานผู้ป่วย 3 ราย สำหรับแก้ปัญหาการขาดเนื้อกระดูกอย่างมากชนิด uncontained defect โดยวิธีนำมาประกอบกันเป็นตัวหนุนสองชั้นและยึดด้วยสารตรึงกระดูก (polymethylmethacrylate) ซึ่งอาศัยหลักการที่โลหะตัวหนุนทั้งสองชิ้นมีสารตรึงกระดูกเคลือบผิวอยู่แล้ว ทำให้เกิดความแข็งแรงจากการยึดด้วยสารตรึงกระดูก*

รูปแบบการรายงาน : *รายงานย้อนหลังเชิงพรรณนา*

วิธีการและเครื่องมือ : *บรรยายวิธีการผ่าตัดเปลี่ยนข้อเข่าเทียมใหม่ในผู้ป่วยที่มีปัญหาขาดเนื้อกระดูกชนิด uncontained defect อย่างมาก โดยเน้นการแก้ปัญหาการขาดเนื้อกระดูกด้วยวิธีใช้โลหะตัวหนุนสองชั้น ยึดติดกันด้วยสารตรึงกระดูก และติดตามผลการรักษาผู้ป่วยจำนวน 3 ราย ค่าเฉลี่ยการติดตามการรักษาประมาณ 11 เดือน และรวบรวมวรรณกรรมที่เกี่ยวข้องกับการรักษาวิธีนี้*

ผลการรักษา : *ผู้ป่วยทั้ง 3 รายมีผลการรักษาที่ดี ทั้งทางคลีนิคและทางภาพรังสี*

ข้อสรุป : *วิธีการแก้ปัญหาการขาดเนื้อกระดูกมากแบบนี้เป็นวิธีที่มีหลักการไม่ยุ่งยากและสามารถนำไปปฏิบัติตามได้ง่าย แต่ทั้งนี้แพทย์ผู้ทำผ่าตัดต้องแต่งกระดูกได้ความสูงที่พอดีกับความสูงที่จะใช้ชิ้นโลหะที่เป็นตัวหนุนชนิด 2 ชั้นนี้จึงอาจมีความเหมาะสมเฉพาะในผู้ป่วยบางรายเท่านั้น ผลของการรักษาโดยวิธีนี้ ในระยะสั้นได้ผลเป็นที่พอใจ แต่อย่างไรก็ตามยังมีความจำเป็นที่ต้องติดตามผลการรักษาระยะกลางและระยะยาว เพื่อประเมินความคงทนของการยึดกันระหว่างชิ้นโลหะตัวหนุนทั้ง 2 ชิ้น*

คำสำคัญ : *Bone defects, Revision, Total knee arthroplasty, Metal augment.*

One major problems in a revision of a total knee arthroplasty is bone loss. Moreover, a large area of bone loss that has no cortical shell (uncontained bone defect) always troubles surgeons. To reconstruct such a defect in a revision of total knee arthroplasty, surgeons have some options of treatment. In young active patients, most surgeons prefer structural allograft to other methods. However, it has limited weight-bearing ambulation which has to be continued for a period of time. Four major complications of allograft are evidenced.[1] Firstly, infection still remains a principal complication of fresh frozen allograft. Second, fractures have not been uncommonly reported. Thirdly, nonunion occurs between graft and host bone at their junction. And finally, resorption, which occurs with all allografts, may cause early failure when it has a rapid dissolution. Other surgeons[2-4] prefer to avoid using structural allograft in the elderly, because of these complications and the delayed weight-bearing ambulation. A custom-made prosthesis seems to be another preference; however, it offers less flexibility, regarding to soft tissue balancing, as well as its costly price. A thick modular augmentation could be beneficial to reconstruct the defect. Given that adequate varieties of modular augments are available, it can provide easy surgical technique for reconstruction. On the other hand, the supply of modular augments is limited in some institutions. As an alternative to the above methods, we hereby, reported a modified technique of management of a large uncontained bone defect with double polymethylmethacrylate (PMMA) precoated modular metal augments in three selected elderly women.

Case report 1

An 83-year-old female patient received her primary total knee arthroplasty of her right knee 18 years ago. Eleven years later, she had her first TKA revision with a hinged prosthesis for her treatment of aseptic bone loosening. Seven years after her first revision, she developed progressive pain and varus deformity of the knee. A radiographic study evidenced a subsidence of the prosthesis with a large uncontained bone defect of the proximal tibia. A CT scan demonstrated the tibial defect was about 35 mm in depth, and it involved the medial and lateral condyles, with a slight depression from posterior to anteromedial side. The distal tibial stem penetrated through the posterolateral cortex and created a hole of 2-cm in diameter. Considering the possibility of complications of allograft and the cost of a custom-made of prosthesis, we decided to use a modified technique for her case.

We performed revision TKA, following the previous antero-medial incision with quadriceps turndown, to provide adequate joint exposure. During the operation, the tibial defect was debrided and prepared with minimal bone cut. Size-3 tibial tray was chosen, and the joint line was estimated at the level that created an uncontained bilateral defect of 38 mm in height. Using the constrained condylar knee system (NexGen LCCK, Zimmer, Warsaw, IN, USA),the femoral size was evaluated. Size-D femoral component and 23-mm polyethylene were selected to provide a good flexion gap at the level of the estimated joint line. With the epicondylar axis, the alignment for femoral AP rotation was set. After the preparation of femoral bone, using bilateral 10-mm distal femoral augment, a balanced extension gap was accomplished. We used the tibial trial components with bilateral 10-mm

on 5-mm trial block modular augments for stability test. After the test, we obtained a stable knee with full range of motion, We bilaterally, screwed and cemented 10-mm block augment together with the tibial base plate. We then bilaterally cemented 5-mm block beneath the 10-mm block to become a 15-mm augment. In addition, we used bilateral 10-mm modular augmentation for the distal femur. Postoperatively, the patient was put in a knee brace, with limited active knee exercise and knee flexion for 6 weeks. Later, she had a progressive active knee exercise and a range of motion.

At her follow-up after 14 months, she did well and suffered no pain on the operated knee, but she still had mild pain on the opposite side. The range of the knee motion was 10-90 degrees. She had 10 degrees of extension lag. Her knee score, based on the standard of the Knee Society, was 30, before the operation and 85 after the operation. The function score before the operation was 20 and after the operation, 45. Radiographic study showed a well-fixed prosthesis without any zones of radiolucency line.

Case report 2

A 79-year-old woman with osteoarthritis of her right knee had a total knee arthroplasty with a hinged prosthesis 10 years ago. She suffered from progressive pain and instability during her walk. Radiographic findings showed loosening of the prosthesis with an uncontained proximal tibia defect and a penetration of the distal tibial stem through the lateral cortex. She received TKA revision with its incision followed the previous anterior one and quadriceps snips. Intraoperatively during the operation, the implant was removed, tibial bone surface prepared, joint line estimated, and tibial defect evaluated, respectively. The tibial size 3 was selected. The medial tibial defect was 38 mm in height and the lateral defect was 12

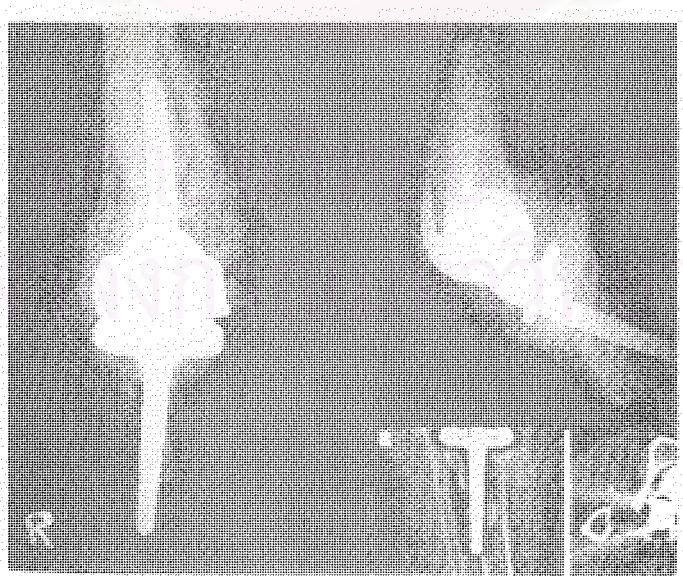

Figure 1. Preoperative radiographs of the right knee of the first patient and the CT images. The loosening hinged prosthesis causes varus deformity of the knee with massive tibial bone loss. The distal stem of the tibial component penetrates through out the tibial cortex.

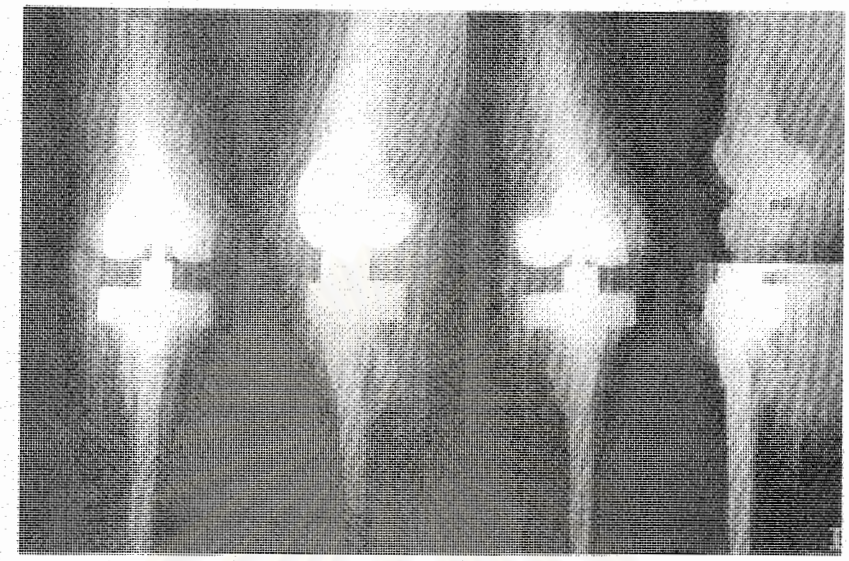

Figure 2. Immediate postoperative radiographs of the first patient compared with 14-month postoperative radiographs reveal that the prosthesis is still well fixed without radiolucency line.

mm in height. Size-D femoral component was selected with distal and posterior defects were bilaterally prepared for 10-mm augments. Stability test was good, and the CCK prosthesis was accomplished with 12-mm polyethylene and augments of the same thickness. We fixed a 10-mm block with a medial tibial plate, and then cemented a 26-degree half-wedge augment that provided the height of 16 mm with the

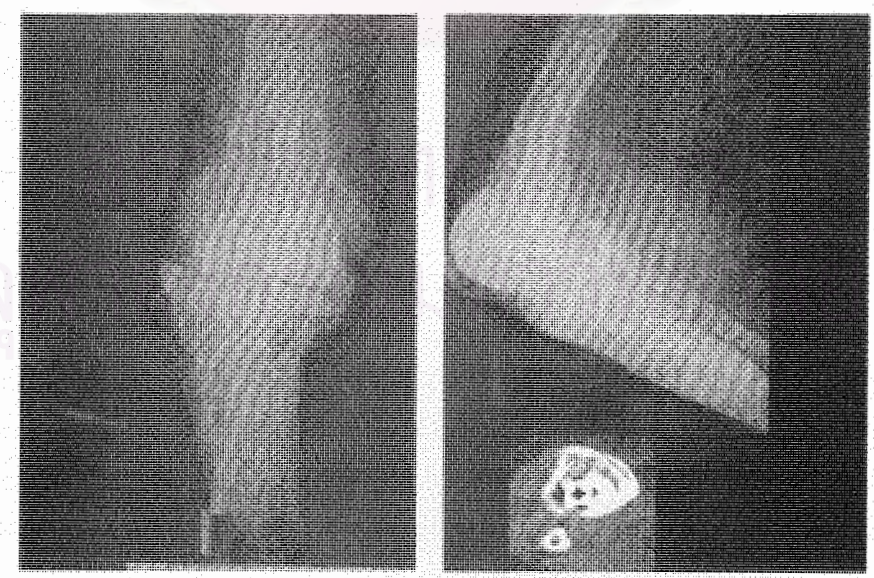

Figure 3. Preoperative radiographs of the right knee of the second patient and the CT images. Bone loss is severe at the medial proximal tibia with loosening of the prosthesis. Like the first patient, the distal stem of the tibial component penetrates through out the tibial cortex.

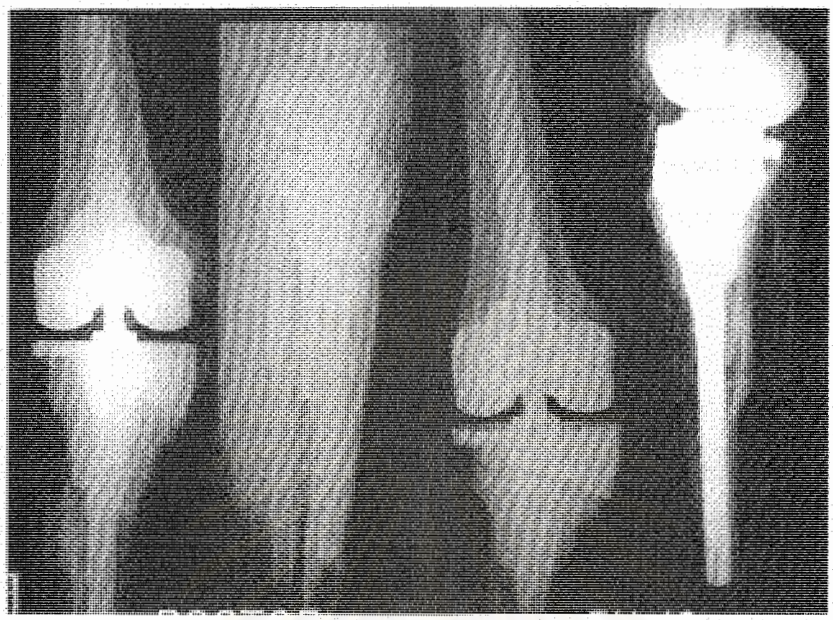

Figure 4. Immediate postoperative radiographs of the second patient compared with 12-month postoperative radiographs show that the prosthesis is well fixed without radiolucency line.

previous block to create a 26-mm-thick augment for the medial tibial side. On the lateral side of the tibial component, we used a conventional 10-mm block. Stability in flexion and extension was achieved with a 12-mm polyethylene and bilateral 10-mm distal and posterior femoral augments on the femoral component, Postoperatively, she could have walking and range of motion ambulation within a few days.

After a follow-up of 12 months, she was found satisfied with the clinical results and a good stability of the right knee. However; she walked with a cane because of the pain on her contralateral knee. The range of motion was 0 -110 degrees. The knee score, based on the standard of the Knee Society, was 15, before the operation, and 80 after the operation. The functional score before the operation was 10, and 30 after the operation. Radiographic study showed a well-fixed prosthesis without any zones of radiolucency line.

Case report 3

A 70-year-old female patient received TKA on her left knee 9 years ago, developed pain in her left knee for 1 year. Radiographic findings and investigation showed that she had aseptic loosening of TKA with marked bone loss on the lateral femoral condyle. We performed a revision surgery with a quadriceps snip for approach to the joint. After adequate exposure, the prosthesis was removed. The remaining bone cement and fibrous tissue were removed. With minimal bone cut at the surfaces of tibia and femur, then we estimated the bone defect and the joint line. We chose size-3 tibial component and size-D femoral component. The tibial defect was minimal and it could be restored with cement, but the distal femoral defect in depth was 20 mm on the lateral side and 10 mm on the medial. The posterior femoral defect was 10 mm in depth, bilaterally. We balanced flexion and extension gaps by selecting the

components and augments that had the same thickness as the depth of the defects' and 17mm polyethylene. Firstly, we fixed the 10-mm distal and posterior femoral augment bilaterally, and then cemented the second distal augment on the lateral side, to provide a 20-mm block for restoration of the lateral femoral defect. After the operation, she could walk and range of motion ambulation within a few days.

Figure 5. Preoperative radiographs of the left knee of the third patient show that marked bone loss at the lateral femoral condyle with loosening of the prosthesis causes knee in valgus alignment.

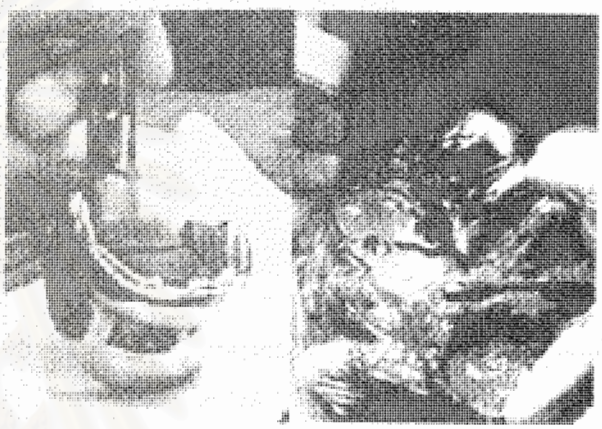

Figure 6. The femoral component is cemented with double augmentation at the distal lateral femoral condyle.

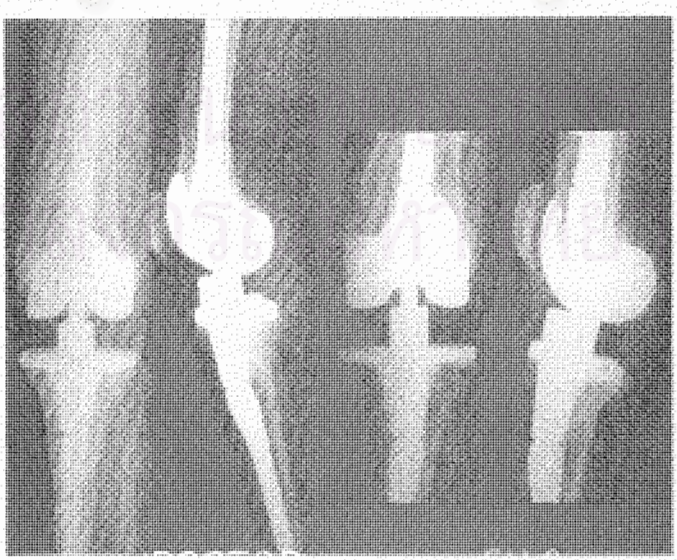

Figure 7. Immediate postoperative radiographs compared to 9-month postoperative radiographs show that the prosthesis is well fixed without radiolucency line.

At the follow-up of 9 months, she did well with a good and stable left knee. Its range of motion was 0-110 degrees, and the knee score, based on Knee Society scale, was 25, before the operation, and 90 after the operation. Its function score was 15 before the operation, and 45 after the operation. Radiographic study showed a well-fixed prosthesis without any zones of radiolucency line.

Discussion

To reconstruct a severe uncontained bone defect in a total knee arthroplasty revision, a few options of treatment can be selected. Reconstruction with allograft can increase bone stock and re-enforce stability. On the other hand, surgeon has to be concerned with 4 major problems[1] namely:, infection, fracture, nonunion and graft resorption. For elderly patients, many surgeons, were concerned about allograft complications,[2-4] might choose another methods, namely:, the use of custom-made prosthesis or a thick modular augmentation. Each method has it own limitation in reconstruction of the defect, i.e., the high cost of the prosthesis and the flexibility of the implants to fill up the defects. The use of metal-wedge augmentation for reconstruction of uncontained tibial defects has been reported since 1984.[5,6] The advantages of the method includes a predictable earlier result, and facilitating revision knee surgery. Brooks et al[5] demonstrated that modular metal wedges were superior because of its building up of proximal tibial peripheral defects to cement or cement reinforced with wire mesh or screws. They proposed that the technique should be considered an acceptable alternative to a custom-made component and might be useful in reconstructing tibial bone stock defects. In a series of 20 patients with an average follow-up time of 37 months, Brand uhjet al [6] reported no failure of using modular metal wedges to augment tibial bone stock deficiency, and suggested the technique for the treatment of severe peripheral tibial deficiencies in the elderly and low-demand patients. In vitro, a study conducted by Chen and Krackow's[7] showed that a conversion of the oblique wedge defect into a stepped pattern improved the rigidity of the cemented tibial component. The findings suggested that block augmentation might reduce cement shear stress and enhance prosthetic stability. Fehring et al[8] found that with tibial stem extension, tibial block augmentation had less tensile strain, compared to the wedge augmentation. Pagnano et al[4] reported results graded from good to excellent in 25 patients who had revision TKA with tibial wedge augmentation at an average follow-up period of 4.8 years. Rand[2,3] preferred the technique for management of peripheral bone deficiency of 3-10 mm remaining after the tibial cut had been performed due to limited thickness of the wedges. Long-term results of modular augments in revision total knee arthroplasty are still unknown.

Park et al[9] made the first improvement of implant-bone cement bond. They polymerized bone cement onto the stem of the implant prior to its insertion into the bone and found that the fixation had improved shear stress. Raab et al[10] reported that thin film polymethylmethacrylate (PMMA) precoated implant improved implant-bone cement fixation.Ahmed et al,[11] in an experimental studying, found that the strength of cement-metal interface of the precoated implant was approximately 10 times greater than an uncoated implant. The PMMA precoating of the stem has been introduced as the first step of the third generation of

cementing technique in total hip arthroplasty since 1980s. The benefits achieved by PMMA precoating are better adhesive bonding of metal to bone cement, prevention of premature failure of the bond caused by body fluid and tissue infiltration at the metal surface. The enhancement of metal-bone cement bond by PMMA precoating results in a significant increase of mechanic of bond in laboratory test.[12,13] It was shown that the well-bond condition of precoated PMMA and bone cement decreased strain in the cement mantle. The technology has been applied for modern knee prosthesis including modular augments. In an experimental study conducted by Muller and Schurmann,[14] the PMMA precoated rod rarely showed any gap formation at the cement-metal interface after immersion in physiologic saline soak for 60 days compared to polished or smooth rod. Ohashi and Dauskardt [15] also reported that the precoated surfaces had markedly enhanced adhesion and fatigue resistance in both air and simulated physiologic environments compared to an uncoated samples.

Concerning chances of complications in revision knee surgery, such as infection, delayed ambulation and early failure, especially in the elderly with a previous surgery, we prefer using the alternative methods for reconstruction of a large bone defect to structural allograft. In fact, a custom-made prosthesis is much more expensive than a constrained one with multiple modular augments. The economical reasons caused us keep the option as the last choice of management. According to the improvement of biomechanical properties of PMMA precoated implants, it is rational to cement 2 pieces of PMMA precoated augments together to become one augment with adequate thickness to fill up a certain bone defect.

To the best of our knowledge, there has been no English literature report on cementing modular augments, together to become a thicker one. At the average period of follow-up of 11 months of our 3 patients, their clinical results were satisfactory. Their radiographic findings showed no evidence of radiolucency.

Although the technique seems easy to manage uncontained bone defects, it is still limited to be applied in every revision case. Preoperatively, patients have to be evaluated carefully. By measuring the defect from radiographs or CT scan and checking the size and the type of available modular augments; surgeons should know the possibility to use the method. It is our suggestion that the trial components with definite sizes and types of augments should be tested for stability before using the real augmented prosthesis. If the preoperative estimation of the height of bone defect is about the maximum thickness of the augment, it would be better to operate with another method, the defects are always worse than what anticipated.

The technique of using precoated augments of modular prostheses as described above, is simple and reproducible. It provides the surgeon more room of confidence for early, and probable long-term, knee stability. In addition, it could minimize risk of early postoperative complications, since patients would be able to take early ambulation with full weight bearing. In a situation that has limited types of modular augmentation for revision knee surgery are supplied, we suggest this technique for selected patients undergoing revision TKA, in whom allograft or custom-made prosthesis is not favorable.

The immediate to short-term clinical results

for the method of treatment is promisingly satisfactory, however, it is necessary to evaluate the intermediate and long-terms follow-up results as well as the radiographic findings.

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