

Results of sleeves in revision total knee arthroplasty: an editorial comment on recently published in the *Journal of Arthroplasty*

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Abstract: The paper entitled “Direct, cementless, metaphyseal fixation in knee revision arthroplasty with sleeves-short-term results” published in the *Journal of Arthroplasty* to analyze the short- and mid-term results in revision total knee arthroplasty (TKA) in a largest series so far. This article shown that cementless metaphyseal fixation with sleeves is a promising option for revision TKA implant fixation. The clinical outcomes regarding the range of motion and the KSS are also promising. Based on this article and related literatures about sleeves, we assess the short to mid-term outcomes and the clinical perspectives in revision TKAs.

Keywords: Sleeves; knee revision arthroplasty; bone defect; metaphyseal fixation; cementless

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The number of revision total knee arthroplasty (TKA) is increasing as the primary TKA becomes widespread (1). This is predicted to continue with an estimated 601% increase from 38,300 to 268,300 between 2005 and 2030 in the United States (2). The annual report of the National Joint Registry (NJR) for England, Wales and Northern Ireland founded that the revision arthroplasty comprised 6.1% of all TKA in 2011 (3), while the revision arthroplasty increased rapidly with a 17% increase in the United Kingdom from 2011 to 2012 (4). Different methods of reconstruction depend on the factors such as the remaining bone stock, integrity of the remaining ligaments and so on. The Anderson Orthopaedic Research Institute (AORI) classification for bone defect provides a useful tool for classifying and scientific guidance for method of reconstruction in revision TKA (5). Bone graft (6), cement and screws (7), block augments (8), tumor mega-prostheses (9) and custom-made prostheses (10) have been used with some success.

Unlike primary TKA which mainly acquired fixation at the solid bone cuts on the joint surface (zone 1), this zone is mostly compromised and cannot be reliably used in revision TKA, so additional fixation in the diaphysis (zone 3) and/

or metaphysis (zone 2) is recommended (11). An alternative option for filling bony defects is the use of porous coated metaphyseal filling implants, which also achieve stable fixation in metaphysis to avoid excess bone resection. There are two distinct technologies implants that have different implantation techniques and philosophies (12): tantalum cones and metaphyseal sleeves. Metaphyseal sleeves have a long history more than 30 years which were used with rotating hinge knee system, while it was until 2005 the metaphyseal sleeves were introduced with posterior stabilized and VVC constraint implants (13). The base component of the sleeve is made of titanium alloy and the porous surface is sintered by titanium with the porosity from 50% to 80%. Biological fixation metaphyseal sleeves of osseous integration not only provide a stabile scaffold of joint reconstruction, but also avoid potential complications of cemented block and wedge augments and the potential disease transmission of allografts (14,15).

On Jun 20, 2015, a paper entitled “Direct, cementless, metaphyseal fixation in knee revision arthroplasty with sleeves-short-term results” published in the *Journal of Arthroplasty* to analyze the short- and mid-term results in a larger revision TKA series. Compared with previously

published smaller series studies (16-18), the 156 patients been analyzed was the largest sample size so far. All the cases were aseptic knee revisions with complete exchange of the implant in a single institution from February 2007 to October 2011. As 18 patients died and 17 patients could not be reached, finally 121 patients were included for re-evaluation. Mean follow-up was 3.6 years (range, 2-6.1 years). The results in 121 patients with 193 sleeves (119 tibial and 74 femoral) were analyzed. Analysis included clinical and radiographic assessments, and a special focus was paid to the analysis of the revision failure reasons and the re-revision surgeries. In all cases, the AORI classification of the tibial side was 114 cases type II defect (77 type IIa and 37 type IIb) and the rest were type III. And the proportion of type III was higher on the femoral side (28 cases), and the rest were type II (46 cases). All surgeries were done by Heiko Graichen or Marco Strauch using the same tibia first, gap balanced technique. In 117 of the 119 tibial sleeves and in 25 patients out of 74 femoral sleeves additional stem were applied.

Sleeves with Morse taper not only provide axial support, but also have excellent rotational stability. The stem provides the immediate support, while the porous coated sleeve with osseous integration provides long-term support. Because of the above theoretical basis, the authors reported promising results of clinical and radiological assessments. The clinical results showed that the ROM, KSS and Function Score improved significantly, with the similar results with the previously published articles. Radiological analysis showed the mean leg axis was changed from $2.1 \pm 2.2^\circ$ varus preoperatively to $0.6 \pm 0.3^\circ$ postoperatively. Most (96.4%) of the sleeves showed good osseous integration. Radiolucent lines could be found in seven sleeves, and three of them have no clinical symptoms.

Although the proportion of radiolucent lines is relative low, special attention should be taken for this problem. It might affect the long term stability, and might be related with loosening if the radiolucent lines progress during the follow-up. Huang *et al.* (12) reported two loosening cases in 119 sleeves (1.7%) and Agarwal *et al.* (16) reported one progressive radiolucent lines in 104 knees. In Alexander's study (17), all implants showed radiographic evidence of osseous ingrowth, and no components had signs of loosening, and Bugler *et al.* (18) came the same results with no loosening. Barnett *et al.* (19) reported four patients with radiolucent lines which were all limited to the tibial plateau adjacent to the tray and did not extend to the sleeve ingrowth surface, and two other patients showed signs of

distal osteolysis, the follow-up results suggested that the osteolysis were focal and quiescent, as a result, none of the patients had sign of loosening. From the above results, many radiolucent lines and osteolysis were limited to the tibial plateau and distal of the stem. The presence of osseous integration to the porous coated surface still provides the stability for the implants.

End-of-stem pain is another complaint usually happened to this reconstruction method. In this study, stem pain on the tibia side was found in two patients (1.7%, one was found a loosening of the tibia implant in a later revision) and in one patient on the femoral stem tip (1.4%). Agarwal *et al.* (16) reports a study with one knee used intramedullary stem on the femoral side, 20 knees used on the tibial side, 78 knees on both sides and 5 knees not used. The results showed no patients had implant stem tip pain on either side. While Alexander *et al.* reported a higher proportion of patients complained of end-of-stem pain (7 patients, 23.3%) in 30 revision TKAs. For more than 2 years conservative treatment, three of the seven patients (10%) remained chronic mild to moderate end-of-stem pain. All the three patients had used the longest diaphyseal stems [up to 150 mm, not statistically significant ($P=0.139$)] and small diameter stems [10-16 mm statistically significant ($P=0.05$)]. The result showed small stem diameter might be a cause. As the limited sample size, it could not to get conclusion that the end-of stem pain was related to slotted versus non-slotted stems (17). Given the different reported results, it may be the different ways of fixation which were applied in different studies. There was no clear explanation for the reason of the end-of-stem pain, so more exploration should be taken into this field.

Fourteen re-revision surgeries (11.4%) have been performed until the follow-up (mean 3.6 years). The reasons for revision were four infections, three instabilities, one malalignment, one extensor mechanism failure, four aseptic loosening and two fractures at the junction between stem and sleeve. All the aseptic loosening happened in rotating hinge implants, and there was no significant difference between stemless and stemmed augmentation. While the two loosen sleeves in Agarwal's study did not have any stems used with them (16). So we should pay special attention handling sleeves with rotating hinge implants or stemless implants. Other complications such as intraoperatively tibial fracture (18,19) and patellofemoral symptoms (18) are recorded in related literatures about sleeves

Despite the advantages of easy surgical technique, the reserve of the limited remaining bone and the promising

results, there are some challenges of the sleeve surgery. The first challenge is the correct placement of the sleeve, and it is difficult to put a proper angle in the coronal and sagittal plane using a metaphyseal sleeve only. Therefore guidance with stem is helpful to solve this problem. The second challenge is how to remove the well-fixed sleeve with the well bone ingrowth in revision surgery.

Although this is so far the largest sample size study in this field, there are some limits for this article. Firstly, it is a relatively short follow-up time. As the re-revision surgery would be much more difficult, good result for long follow-up time results to avoid re-revision surgery would be important. Secondly, the implants were fixed by different ways such as stem or stemless, it might bring confounding factor. Thirdly, the lack of a control group as well as non-randomized patient selection reduces the level of evidence of the study.

In conclusion, recent studies had shown easy surgical technique, excellent bone ingrowth and promising short to mid-term results. Sleeves could be a promising option to deal with large bone defect (AORI II and III) in revision TKAs both tibia side and femoral side. Meanwhile, we should pay attention to the end-of-stem pain and failure in revision, and we should handle these problems properly.

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Footnote

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