Arthroplasty Today 9 (2021) 16–20

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Surgical technique

# Technical Note for Transfemoral Implantation of Tapered Revision Stems. The Advantage to Stay Short

Bernd Fink, MD *

*Orthopaedic Clinic Markgröningen, Joint Replacement, General and Rheumatic Orthopaedic, Markgröningen, Baden-Württemberg, Germany*
*University-Hospital, Hamburg-Eppendorf, Orthopaedic Department, Hamburg, Germany*

ARTICLE INFO

*Article history:*
Received 16 December 2020
Received in revised form
19 March 2021
Accepted 21 March 2021
Available online 24 April 2021

*Keywords:*
Hip revision arthroplasty
Tapered revision stem
Periprosthetic fracture
Subsidence

ABSTRACT

*Background:* The aim was to test the hypothesis that during transfemoral implantation of a conical revision stem, the fixation of the stem at the distal tip leads to a low rate of periprosthetic fractures.
*Material and Methods:* Two hundred eighty-two stem revisions by a transfemoral approach in cases of Paprosky Type II and IIIA-defects (with a sufficient isthmus) were carried out and analyzed during and radiographically after the surgery for unintentional periprosthetic fractures below the osteotomy.
*Results:* In all cases, fixation was always achieved at the tip of the distal component in the isthmus of the femur. No periprosthetic fractures were observed.
*Conclusions:* When the isthmus of the femur is intact, a transfemoral implantation of a tapered revision stem at the distal end reduces the risk of periprosthetic fractures by preventing bypassing the isthmus with the stem. Knowing the difference between the nominal diameter and the diameter at the distal start of the conical zone can help to create this fixation technique resulting in short revision stems.


## Introduction

Distally fixed, cementless tapered revision stems represent a successful concept for the revision of hip prostheses [1-8]. This type of revision stem is available in a monobloc form or in a modular version, the former with a straight stem and the latter with a straight or curved stem. A common feature for most versions is that a conical reamer (for a straight stem) or a conical rasp (for a curved stem) is used to create a conical anchorage bed in the femur. The conical stem is inserted into this bed so that a firm cone-in-cone fixation is achieved [5,9].

The implantation can either be done endofemoral or transfemoral (with an extended trochanteric osteotomy). In transfemoral revisions with an intact isthmus of the femur, cone-in-cone fixation in the isthmus takes place over a distance defined by the preparation (with the conical reamer of rasp) [9,10]. In 2 degree tapered stems, this fixation can take place at the distal end of the stem or the distal component (in modular stems) (Fig. 1a-c) [9,10]. The use of longer stems or distal components does not lead to a longer fixation zone, but to an equally long fixation zone further proximally on the stem (Fig. 2) [10]. This in turn leads to the stem passing through the isthmus, which increases the rate of unintentional fractures, especially when straight revision stems are used [10]. Many authors have given fracture rates with conical revision stems of over 10% [11-20], in some cases even over 20% [21-24]. These fracture rates should be able to be reduced by fixing the stem in the isthmus without bypassing the isthmus with the stem. The aim of this work was therefore to test the hypothesis that during transfemoral implantation of a conical revision stem, the fixation of the stem at the distal tip in the isthmus resulting in shorter stems leads to a low rate of unintentional periprosthetic fractures.

## Material and Methods

Two hundred eighty-two stem revisions by a transfemoral approach using a previously published modified Wagner technique in cases of Paprosky Type II and IIIA-defects (with a sufficient isthmus) were carried out between July 2004 and June 2018 [25,26]. These were 151 women and 131 men with an average age of 67.1 ± 10.1 (44 - 95) years and a BMI of 28.7 ± 5.1 (19.3-40.9). These were 194 aseptic and 88 septic revisions; 110 times the first

* Corresponding author. Bernd Fink, MD, Orthopaedic Clinic Markgröningen, Joint Replacement, General and Rheumatic Orthopaedic, Kurt-Lindemann-Weg 10, Markgröningen, Baden-Württemberg, 71706, Germany, +49-7145-9153201.
*E-mail address:* bernd.fink@rkh-kliniken.de.

https://doi.org/10.1016/j.artd.2021.03.015

revision, 122 times the second, 40 times the third, and 10 times the fourth revision. The indication for a transfemoral approach was determined during preoperative planning. According to the previous published indications of Paprosky et al. [27,28] and Fink et al. [25,26,29,30], the transfemoral approach was performed in the following conditions: always in cases of broken endoprosthesis stems (5 cases) or only partially loosened cementless stems with a coarsely porous structure (33 cases) to remove the stem. In cases of cemented stems, where the cement could not be completely removed using the endofemoral approach, the transfemoral approach was also adopted for the surgical operation (56 cases). A transfemoral approach was also chosen during preoperative planning when the femoral axis was so deformed by loosening of the prosthesis that it had to be corrected by osteotomy (63 cases) [25-28]. Furthermore, periprosthetic fractures, where the implant was loose, were revised via a transfemoral approach (37 cases) [29,30]. In septic two-stage revisions, the transfemoral route was used to remove the infected but well-anchored cementless stems or well-cemented stems with septic osteolysis [31]. In these 88 cases, the transfemoral approach was reopened in the second stage to replace the spacer with the new prosthetic implant.

The transfemoral approach was carried out using a previous published modified Wagner technique [25,26,30]. After a posterolateral incision, the posterolateral edge of the femur ventral to the linea aspera was exposed in the septum intermusculare laterale after ligation of the perforating vessels. The lateral circumference of the femur was exposed in the area where the end of the osteotomy flap was going to be positioned and 2 3.2-mm holes drilled under cooling (above the linea aspera and 180 degrees ventromedial from the first hole) (Fig. 3a). The ventromedial trochanter region was osteotomized using a chisel at the vasto-gluteal border, and then the dorsolateral osteotomy, the connecting osteotomy between the 2 drill holes, and the distal ventromedial osteotomy of about 3 cm were performed with a water-cooled oscillating saw (Fig. 3a). The ventromedial osteotomy was completed with a chisel that was introduced into the already prepared distal, ventral osteotomy and then driven blind under the vastus lateralis muscle to the proximal end of the osteotomy. The flap with the vastus lateralis muscle attached was opened in a ventromedial direction (Fig. 3b). Before preparing the fixation bed in the isthmus of the femur, a prophylactic double cerclage wire distal to the osteotomy was placed (Fig. 3b). After implantation of the revision stem, the closure of the bone flap was achieved most of the time with the aid of 2 double cerclages using 1.5-mm cerclage wire (Fig. 1b and c).

The modular cementless revision system Revitan Curved (ZimmerBiomet GmbH, Winterthur, Switzerland) was used in all cases. It is based on the principles of the Wagner SL-stem (ZimmerBiomet GmbH, Winterthur, Switzerland) and consists of a distal curved component with a thickness ranging from 14 mm to 28 mm (in 2-mm steps) and lengths of 140 mm, 200 mm, and 260 mm which can then be combined with the proximal component with a length ranging from 55 mm to 105 mm (in 10-mm steps). The curved distal component has an octagonal cross-section and is tapered at an angle of 2 degrees. The rotational stability of the implant is achieved by the spline peaks of the octagonal form that run along the whole length.

Because of the known difference between the diameter at the distal start of the conical area and the nominated stem thickness of 3.8 mm after reaming the cortical canal with a flexible reamer until solid cortical contact was reached, a distal component of 140 mm

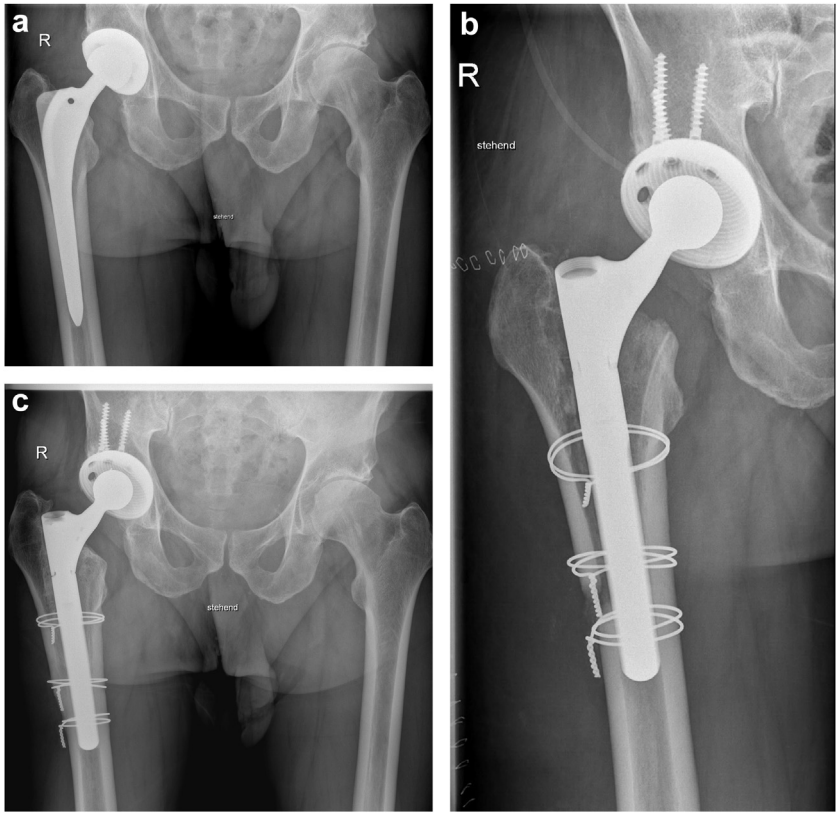


**Figure 1.** (a) A 73-year-old man with infected well-osteointegrated cementless hip arthroplasty on the right side. (b) Postoperative radiograph after transfemoral reimplantation of a modular revision stem Revitan curved and a press-fit cup (Allofit S; ZimmerBiomet, Winterthur, Switzerland) 6 weeks after transfemoral removal of the infected implants and temporary spacer placement. (c) Radiograph done 2.5 years postoperatively showing a complete osteointegration of the implants and healing of the approach and osteotomy.

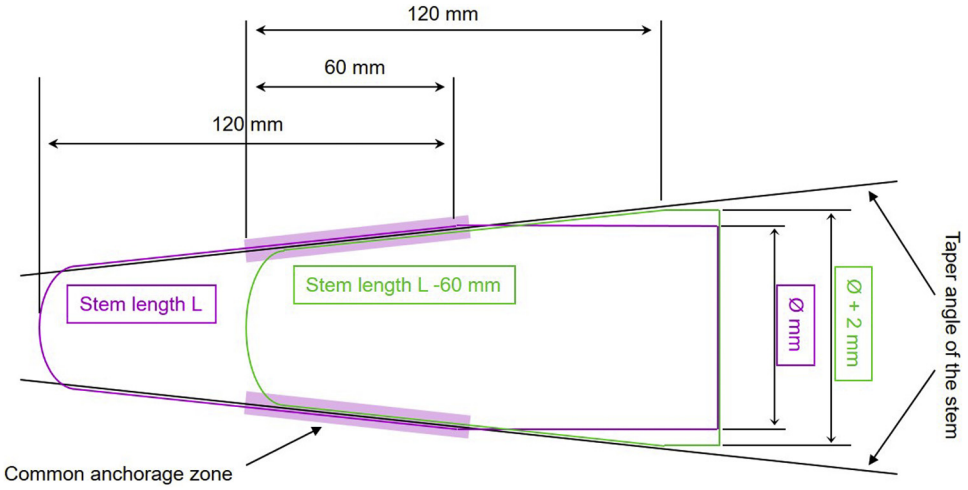


**Figure 2.** Comparison of a shorter and longer distal component concerning the position of the fixation zones in the isthmus of the femur at the stem.

length (in 276 cases) or 200 mm length (in 6 cases) and a nominated thickness of 4 mm larger than the last reamer was inserted. This was done after stepwise preparation of the conical femoral fixation zone with the conical rasps (last rasp of 4 mm lager than the last reamer). By this, a fixation zone of 3 to 5 cm at the tip of the distal component in the isthmus of the femur was reached (Fig. 1a-c).

Postoperatively, the leg was subjected to partial weight-bearing by loading with 10 to 20 kg for a period of 6 weeks. Thereafter, the weight-bearing was gradually increased to full weight-bearing 3 months postoperatively similar to how other authors did for other cementless revision stems [1,4,6,14]. The hip joint was not allowed to be flexed for more than 70° for 6 weeks after the operation to avoid movement of the bone flap [10,26].

The incidence of periprothetic fractures was determined intraoperatively and postoperatively by radiological examination. All patients were followed up for at least 2 years for radiological analysis of loosening or subsidence. Five patients (with 5 revision stems) died from causes unrelated to the revision operation before the 2-year minimum follow-up period was reached, and 5 patients were lost to follow-up, so that a total of 272 stems from 270 patients were followed. Subsidence of the stem was assessed by comparing all the postoperative radiographs using the technique described by Challaghan et al. [32] and McInnis et al. [22]. Hereby, vertical subsidence of the femoral component was measured as the change in the distance from the inferior margin of the component neck to the most proximal point on the lesser trochanter and from the proximal lateral end of the component body to the tip of the greater trochanter. Any subsidence greater than 5 mm was classified as significant in accordance with the study by Pattyn et al. [3] and van Houwelingen et al. [6]. The osteotomy site was considered to be radiologically healed if callus was seen bridging the site in both the anteroposterior and lateral planes in agreement with the study by Chen et al. [33] and Miner et al. [34]. The mean follow-up period was 7.44 ± 2.09 years (2 - 15 years). All subjects gave informed consent to participate in the study, and the protocol was approved by the research ethics board of the respective institution.

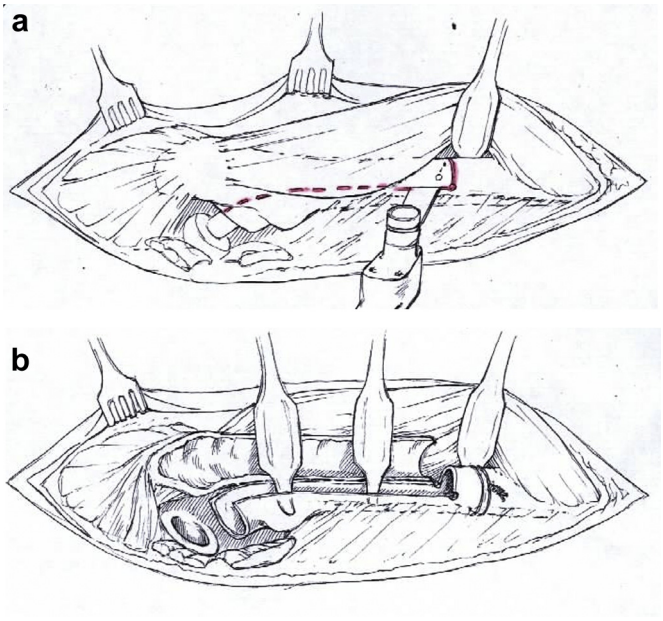


**Figure 3.** (a) Diagram showing the localization of the flap of the modified transfemoral approach. (b) Diagram showing the opened flap of the transfemoral approach.

## Results

In all 282 cases, fixation was always achieved at the tip of the distal component in the isthmus of the femur (Fig. 1a-c). The mean circular press-fit fixation zone at the tip of stems implanted was 4.13 ± 0.86 cm (3.0-5.3 cm). The mean length of the flap created during the transfemoral approach was 17.7 ± 3.3 cm (12.2-24.0 cm). The mean length of the implanted stems was 214.9 ± 16.4 mm (195-265 mm), and the mean nominal diameter (name of the thickness of the stem) was 18.6 ± 2.5 mm (14-24 mm).

No unintentional periprosthetic fractures below the transfemoral approach which would weaken the fixation zone of the new revision stem were observed. During implantation of the original distal component, a fissure at the beginning of the isthmus was observed 8 times (2.8%). They were treated with additional double cerclage wires and healed without subsidence of the stem. Nonprogressive subsidence was seen in 6 of the 272 cases with follow-up examination (2.2%). There was no case of loosening. Nonunion of the bony flap was seen in 2 cases (0.7%) of a two-stage septic revision. Other complications included 7 dislocations (2.6%) that could be treated conservatively in 5 cases and needed revision surgery in 2 cases as well as 3 cases of thrombosis (1.1%).

**Table 1**
Features of different monoblock and modular tapered revision stems.

| Stem | Company | Modularity | Straight/curved | Degree of conicity | Difference of nominal diameter and the diameter at the distal start of the conical area |
|---|---|---|---|---|---|
| Arcos | Zimmer-Biomet (Warsaw, IN) | Modular | Straight | 3 | 150 DC: 4.17 mm for ND 12 to 3.70 mm decreasing for ND 30<br>190 DC: 6.32 mm fori ND 12 to 5.85 mm decreasing for ND 30 |
| MRP | Peter Brehm (Weisendorf, Germany) | Modular | Straight 80, 140, 200 curved | 2 | 4 mm for 80, 140, and 200 DC |
| MP | Waldemar Link (Norderstedt, Germany) | Modular | 3° Kinked | 2 | 2.5 mm |
| Mutars R | Implantcast (Buxtehude, Germany) | Modular | Curved | 1,5 | 4 mm for 150 and 200 DC |
| Prevision | Aesculap (Tuttlingen, Germany) | Modular | Straight<br>Curved | 2<br>0,6 | 1 mm |
| Profemur R | MicroPort Orthopedics (Shanghai, China) | Modular | 135 DC mm straight<br>175 and 215 mm DC curved | 2 | 0 mm |
| Reclaim | DePuy Synthes (Warsaw, IN) | Modular | 140 mm straight<br>190 mm straight and 3° kinked<br>240 and 290 mm 3° kinked | 2,5 | 4 mm for 140 DC<br>6 mm for 190 DC |
| Redapt | Smith & Nephew (London, GB) | Mono-block + with Sleeve | Straight | 3 | 3 mm for 190 stem<br>5 mm for 240 stem |
| Restor-ation | Stryker (Kalamazoo, MG) | Modular | Straight | 3 center<br>2 rips | 4 mm |
| Revitan | Zimmer-Biomet (Winterthur, Switzerland) | Modular | Straight and curved series | 2 | 3.8 mm |
| Wagner SL | Zimmer-Biomet (Winterthur, Switzerland) | Mono-block | Straight | 2 | 3.8 mm |
| ZMR | Zimmer-Biomet (Warsaw, IN) | Modular | Straight | 3,5 | 6.1 mm for ND 17-19<br>6.0 mm for ND ≥ 20 |

DC, distal component in modular stems; ND, nominal diameter.

## Discussion

This study was designed to investigate whether the consistent fixation of tapered revision stem at the distal tip in an intact isthmus of the femur leads to low rate of periprosthetic fractures. We could show that in these defect types of Paprosky II and IIIA, short stems with the short distal component of 140 mm length can be used on a regular basis to achieve reproducibly good results with preventing unintentional periprosthetic fractures and a very low rate of fissures. Moreover, as in previous studies, we could show that with this technique also reproducible good results concerning aseptic loosening and subsidence of the stem could be achieved [5,10]. Russell et al. [35] concluded in a biomechanical study that 1.5- to 2.5-cm cone-in-cone-fixation at the tip of a tapered revision stem (Wagner SL with 2 degree taper) seems to result in sufficient stability. We showed for the clinical use of the Revitan curved stem (with 2-degree taper) that the minimum fixation-zone seems to be 3 cm [5,36].

The constant fixation at the tip of the stem could be achieved in our study by knowing the difference between the nominal diameter and the diameter at the distal beginning of the conical zone. For the stem we used, this difference was 4 mm (exact 3.8 mm). This principle should also work when using other conical revision stems if the difference between the nominal diameter and the distal start of the conical segment is known. According to the companies, we have therefore summarized this difference for the shorter distal components of the common tapered revision stems in Table 1. In order to implement this procedure and operative technique even with tapered straight stems, the isthmus would first be cylindrically reamed with flexible medullary reamers to determine the stem thickness. The conical fixation bed for the cone-in-cone fixation of the revision stem would then be created with the conical reamers for the straight stems. However, it must be taken into account that the fixation starting at the distal tip of the stem is only possible with 2-degree tapered stems. In the case of stems with a higher degree of taper, the fixation zone cannot begin directly at the distal tip. The higher the degree of conicity is, the more it migrates proximally (Fig. 4). Thus, even with higher degrees of conicity, the fixation cannot begin directly at the distal tip and thus for the nominal diameter of the selected distal component, the whole difference to the diameter at the distal end of the conical segment cannot be added completety. For example, the difference between the nominal diameter and the diameter at the distal tip of the ZMR stem (with a taper of 3.5 degrees) is 6.1 mm or 6.0 mm. Here the fixation cannot begin directly at the tip of the stem.

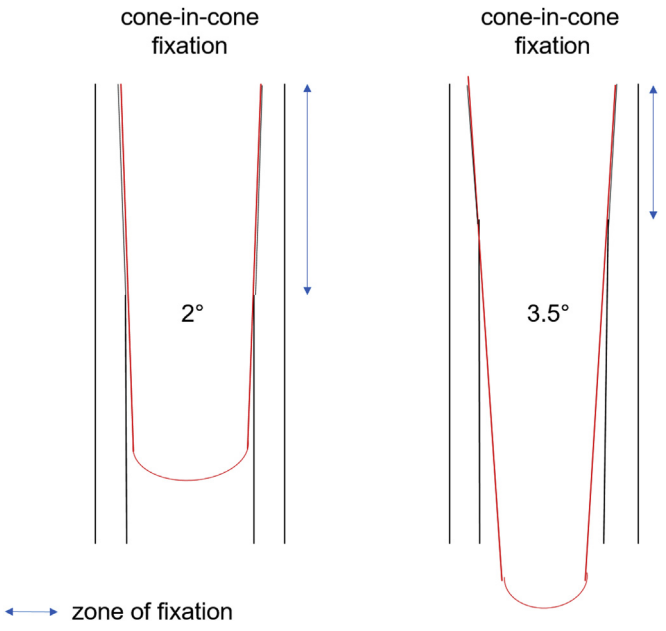


**Figure 4.** Comparison of the fixation zone at the distal component between a 2-degree tapered stem (left) and a distal component with 3.5 degree taper (right).

Therefore, the selected stem will be nominally 5 or 4 mm thicker than the last medullary reamer which had a solid cortical contact in the isthmus. Using this technique results in extension of the stem from the distal end of the osteotomy of 3 to 5 cm with a 2 degree tapered stem (Fig. 1b and c) and in an increasing extent with increasing conicity of the stem (Fig. 4) [9,10,36]. The fixation zone of the stem can be controlled intraoperatively with an imaging intensifier.

The technical rule (of +4 mm in the stem we used) can only be used when implanting the stem via a transfemoral procedure. Owing to the different shapes of the femoral bone and the implanted stems (especially in straight stems), the difference between the last flexible reamer and the original stem is individual for endofemoral implantation (2 or 3 mm in the Revitan Curved).

In conclusion, it can be said when the isthmus of the femur is intact, a transfemoral implanting of a tapered revision stem at the distal end reduces the risk of periprosthetic fractures by preventing bypassing the isthmus with the stem. Knowing the difference between the nominal diameter and the diameter at the distal start of the conical zone can help create this fixation technique resulting in short revision stems.

## Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article. The author is a consultant for ZimmerBiomet.

## References


[1] Böhm P, Bischel O. The use of tapered stems for femoral revision surgery. Clin Orthop Relat Res 2004;420:148.
[2] Artiaco S, Boggio F, Titolo P, Zoccola K, Bianchi R, Bellomo F. Clinical experience in femoral revision with the modular Profemur R stem. Hip Int 2011;21:39.
[3] Pattyn C, Mulliez A, Verdonk R, Audenaert E. Revision hip arthroplasty using a cementless modular tapered stem. Int Orthop 2012;36:35.
[4] Wirtz DC, Heller KD, Holzwarth U, et al. A modular femoral implant for uncemented stem revision in THR. Int Orthop 2000;24:134.
[5] Fink B, Urbansky K, Schuster. Mid term results with the curved modular tapered, fluted titanium Revitan stem in revision hip replacement. Bone Joint J 2014;96-B(7):889.
[6] van Houwelingen AP, Duncan CP, Masri BA, Greidanus NV, Garbuz DS. High survival of modular tapered stems for proximal femoral bone defects at 5 to 10 years follow-up. Clin Orthop Relat Res 2013;471:454.
[7] Köster G, Wald TA, Willert HG. Five- to 10-year results using a noncemented modular revision stem without bone grafting. J Arthroplasty 2008;23:964.
[8] Kwong LM, Miller AJ, Lubinus P. A modular distal fixation option for proximal bone loss in revision total hip arthroplasty. A 2- to 6-year follow-up study. J Arthroplasty 2003;18:94.
[9] Fink B, Hahn M, Fuerst M, Thybaut L, Delling G. Principle of fixation of the cementless modular revision stem Revitan. Unfallchirurgie 2005;108:1029.
[10] Fink B, Buntenbroich U, Oremek D. Fixation of a modular curved revision stem with a taper of two degrees in the femur. Arch Orthop Trauma Surg 2019;139:127.
[11] Ammanatullah DF, Howard JL, Siman H, Trousdale RT, Mabry TM, Berry DJ. Revision total hip arthroplasty in patients with extensive proximal femoral bone loss using a fluted tapered modular femoral component. Bone Joint J 2015;97-B:312.
[12] Desai RR, Malkani AI, Hitt KD, et al. Revision total hip arthroplasty using a modular femoral implant in Paprosky III and IV femoral bone loss. J Arthroplasty 2012;27:1492.
[13] Giutiérrez del Alamo J, Garcia-Cimbrelo E, Castellanos V, Gil-Garay E. Radiographic bone regeneration and clinical outcome with the Wagner SL revision stem. A 5-year ot 12-year follow-up study. J Arthroplasty 2007;22:515.
[14] Klauser W, Bangert Y, Lubinus P, Kendoff D. Medium-term follow-up of a modular tapered titanium stem in revision total hip arthroplasty: a single-surgeon experience. J Arthroplasty 2013;28:84.
[15] Park YS, Moon YM, Lim SJ. Revision total hip arthroplasty using a fluted and tapered modular distal fixation stem with and without extended trochanteric osteotomy. J Arthroplasty 2007;22:993.
[16] Regis D, Sandri A, bonetti I, Graggion M, Bartolozzi P. Femoral revision with Wagner tapered stem. A ten-to 15 year follow-up study. J Bone Joint Surg Br 2011;93-:1320.
[17] Revision Total Hip Arthroplasty Study Group. A comparison of modular tapererd versus modular cylindrical stems for complex femoral revisions. J Arthroplasty 2013;28(8 Suppl):71.
[18] Park YS, Lim SJ. Long-term comparison of porous and hydroxyapatite sleeves in femoral revision using the S-ROM modular stem. Hip Int 2010;20:179.
[19] Wang L, Dai Z, Wen T, Li M, Hu Y. Three to seven year follow-up of a tapered modular femoral prosthesis in revision total hip arthroplasty. Arch Orthop Trauma Surg 2013;133:275.
[20] Zhang ZD, Zhuo Q, Zhang QM, Song JL, Yang F, Chen JY. Application of modular cementless femoral stems in complex revision hip arthroplasty. Zhongguo Gu Shang 2015;28:198.
[21] Grünig R, Morscher E, Ochsner PE. Three- to 7-year results with the uncemented SL femoral revision prosthesis. Arch Orthop Trauma Surg 1997;116:187.
[22] McInnis DP, Horne G, Devane PA. Femoral revision with a fluted, tapered, modular stem. Seventy patients followed for a mean of 3.9 years. J Arthroplasty 2006;21:372.
[23] Weber M, Hempfing A, Orler R, Ganz R. Femoral revision using the Wagner stem: results at 2-9 years. Int Orthop 2002;26:36.
[24] Zang J, Uchiyama K, Moriya M, Fuksuhima K, Takahira N, Takaso M. Long-term outcomes of Wagner self-locking stem with bone allograft for Paprosky typee II and III bone defects in revision total hip arhroplasty: a mean 15.7 year follow-up. J Orthop Surg 2019;27:1.
[25] Fink B, Grossmann A. Modified transfemoral approach to revision arthroplasty with uncemented modular revision stems. Oper Orthop Traumatol 2007;19:32.
[26] Fink B, Grossmann A, Schubring S, Schulz MS, Fuerst M. A modified transfemoral approach using modular cementless revision stems. Clin Orthop Relat Res 2007;462:105.
[27] Paprosky WG, Lawrence J, Cameron H. Femoral defect classification. Clinical application. Orthop Rev 1990;19(Suppl):9.
[28] Paprosky WG, Greidanus NV, Antoniou J. Minimum 10-year results of extensively porous-coated stems in revision hip arthroplasty. Clin Orthop Relat Res 1999;369:230.
[29] Fink B, Grossmann A, Singer J. Hip revision arthroplasty in periprosthetic fractures of Vancouver Typee B2 and B3. J Orthop Trauma 2012;26:206.
[30] Fink B. Revision arthroplasty in periprosthetic fractures of the proximal femur. Oper Orthop Traumatol 2014;26:455.
[31] Fink B, Oremek D. The transfemoral approach for removal of well-fixed femoral stems in two-stage septic hip revision. J Arthroplasty 2016;31:1065.
[32] Challgahan JJ, Slavati EA, Pellicci PM, Wilson PD, Ranawat CS. Results of revision for mechanical failure after cemented total hip replacement, 1979 to 1982. A two to five-year follow-up. J Bone Joint Surg 1985;67-A:1074.
[33] Chen WM, McAuley JP, Engh Jr CA, et al. Extended slide trochanteric osteotomy for revision total hip arthroplasty. J Bone Joint Surg Am 2000;82:1215.
[34] Miner TM, Momberger NG, Chong D, et al. The extended trochanteric osteotomy in revision hip arthroplasty: a critical review of 166 cases at mean 3-year, 9-month follow-up. J Arthroplasty 2001;16:188.
[35] Russell RD, Pierce W, Huo MH. Tapered vs cylindrical stem fixation in a model of femoral bone deficiency in revision total hip arthroplasty. J Arthroplasty 2016;31:1352.
[36] Fink B, Grossman A, Schubring S, Schulz MS, Fuerst M. Short-term results of hip revisions with a curved cementless modular stem in association with the surgical approach. Arch Orthop Trauma Surg 2008;129:65.