Mid-term results of revision total hip arthroplasty using the oval-shaped uncemented Trč-Cingr cup

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Abstract

Purpose The aim of the present study was to introduce a novel oblong revision cup type TC for use in revision total hip arthroplasty (THA), and to evaluate mid-term results in terms of bone tissue remodelling in the immediate area of the implant.

Methods The results of 31 patients that underwent revision THA between 2004 and 2008 are presented. The mean follow-up interval was 7.1 years (range 5.3–9.3 years, minimum of five years following revision). Osteointegration of the implant and bone tissue remodelling around the implant and ribs were assessed by X-ray and computed tomography (CT).

Results The average Harris hip score increased from 39.8 to 85.3. Excellent results were achieved in nine patients, good in 16, fair in three and poor in three. According to X-ray results, 25 hips had a well-fixed, bone-ingrown cup and five had a stable fibrous union in the middle and the distal third of the implant. Proximal migration of the cup was noted in one case. Pelvic CT was additionally performed in ten patients. In all cases, we detected bone remodelling in the space between the implant ribs. Kaplan-Maier survivorship of the acetabular components was 94.2 % at 7.1 years.

Conclusions Our results show that the novel oblong revision cup type TC is relatively simple to implant, and is associated

with reliable primary fixation and documented osteointegration and bone remodelling in the immediate area.

Keywords Revision oval cup · Bone tissue remodelling · Pull-out test · Locking screws · Computed tomography

Introduction

Revision THA is nearly always a demanding orthopaedic procedure. In the majority of cases, the procedure is required due to loose contact between the bone and implant, which generally migrates proximally, medially and dorsally. The direction and extent of migration depends on the position of the original artificial acetabulum and on the quantity of bone cement used. Removing the original arthroplasty and anchoring a new implant in the defective acetabulum is always an extensive intervention. The choice of implant should always correspond to bone tissue quality. The S-ROM system, which we used previously, didn't fulfil our expectations from the perspective of preserving and remodelling bone tissue. Except in cases of a spherical acetabulum with minimal bone destruction and severe osteolysis up to pelvic discontinuity, our centre uses a cementless oblong cup, type TC. Along with sufficiently filling acetabular space defects resulting from primary cup migration, enabling firm and reliable peri-operative fixation and documented postoperative secondary fixation, this cup is designed to promote bone healing. Therefore, the defect should be reduced over time, rather than deepened.

In 2003 we began cooperation with the Beznoska company (Kladno, Czech Republic) in the development of a new revision cup, type TC. This cup was used for the first time in a clinical trial in our department in April 2004. The first ten patients were closely followed by the State Institute for Drug Control using strict clinical trial criteria. Initial experience was evaluated in 2005, and the first results five years later [20].

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Favourable results led to the adaptation of the TC cup as a standard implant at our department. Taking into consideration biomechanical studies, the implant was complemented by fixed-angle screws, enabling more rigid fixation of the proximal part.

The aim of the present study was to introduce the new revision cup, to verify bone tissue remodelling in the surrounding area and to evaluate mid-term results in a group of 31 patients.

Implant and surgical technique

The type TC (Trč-Cingr, Kladno, Czech Republic) oblong revision cup is manufactured from Ti6Al4V titanium alloy, and its design is derived from the type SF (Slavík-Fencel, Kladno, Czech Republic) spherical cup [18]. The original spherical cup (50 mm, 56 mm, 64 mm) is adapted to an oblong shape by adding five ribs, which extend the cup into a 12-mm or 18-mm oval shape (the transverse diameter of the implant is shorter than the longitudinal diameter by 12 or 18 mm). Its shape therefore enables the filling of proximal (defective) parts with smaller, narrower and spatially non-homogenous ribs (Fig. 1), which significantly contributes to better secondary fixation. The cup surface is matted with a titanium spray coating in the area of presumed contact with the bone in the distal third (titanium spray thickness of 0.25 ± 0.05 mm, surface roughness of 8–15 μm , porosity of 30–40 %, porosity of 0.05–0.25 mm).

To prepare the upper (defective) part of the acetabulum to the exact shape, there is a more complex but absolutely precise guide for the burr, which is used to mill the bed to the desired oblong shape with the smaller proximal part. The fixed part of the guide is inserted and anchored to the distal prepared part of the acetabulum. Following this, the burr, with a diameter 6–10 mm smaller than the burr diameter used in the distal part of the acetabulum, is anchored into the guide template and milling of the bed is finished, achieving a proximal oblong shape. Defects of bone stock and spaces from anchoring holes are then filled with spongy bone so that it does not cover the whole surface of the acetabulum. Spongy bone is

applied between the ribs before insertion of the implant (or afterwards), while filling the spaces along the casing of the cup. Unused holes are covered with plugs. Optimal cases allow press-fit implantation.

At the apex of the two ribs, guide holes are drilled with threads for two spongy (or fixed-angle) screws, which reach the iliac bone when correctly centred, or more precisely, when the cup has a correct inclination. As the cup is mostly inclined in the proximal-dorsal direction because of the bone defect, it is always possible to infix the anterior screw; the bottom of the casing has holes for two multidirectional screws. There are two holes in the distal part to drill screws into the ischium and pubic bone (cortical and spongy titanium screws with a length of 15–55 mm in increments of 5 mm). The space between the ribs enables the application of further horizontal cortical screws. When needed, one can lead a distal hook through the foramen obturatorum that is anchored in the scale-like groove of the endoprosthesis via a secured safety screw. Since 2007, the polyethylene spherical liner has been manufactured from cross-linked ultra-high molecular weight polyethylene (symmetrical or with an off-set of 10°). The position of the distal 2/3 of the titanium casing contributes to the renewal of the anatomic centre of rotation and is designed for heads with a diameter of 28 and 32 mm.

Methods

We used the oblong type TC cup in revision THA on 43 patients between 2004 and 2008. Seven patients from this group died (unrelated to hip arthroplasty, and with no signs of implant loosening at the last clinical follow-up), three patients failed to attend follow-up, one patient suffered dislocation of the cup due to severe trauma 18 months after revision surgery and in one patient there was septic loosening with extensive acetabular destruction noted six months after surgery. In 2013, we reviewed 31 patients with a mean follow-up period of 7.1 years (range 5.3–9.3 years, minimum of five years following revision). The group included 21 women and ten men. The mean age at the time of implantation was 69 years (range 41–81 years). The left hip was operated on in

Fig. 1 **a** TC cup with screws inserted in implant ribs and a distal hook fixation. **b** Titanium spray coating on the distal third of the implant

15 cases and the right hip in 16 cases. The majority of cases required revision THA after aseptic loosening of the cemented cup, and three patients required two-stage re-implantation secondary to deep seated infection.

In the pre-operative period, we noted age, gender, body mass index (BMI), exercise activity and pre-surgical diagnosis.

Peri-operatively, we classified the type of acetabular defect, the size of the revision implant, the quality of the primary fixation of the implant, and the number and positioning of screws. All surgeries were performed on patients in the supine position. To replace the cup, a Bauer approach in 21 patients and a modified Watson-Jones approach in ten patients were used. Defects were assessed perioperatively according to Paprosky classification: 2A in two patients, 2B in eight, 2C in 12, 3A in eight and 3B in one patient. The most frequently used implant size was 56/68 in nine cases, followed by 64/76 in 11 cases, 64/82 in three cases, 56/74 in six cases and 50/62 in two cases (size 50/68 was not used). A polyethylene liner with a 10° off-set was used in 19 cases. The mean number of screws used was 3.7 (range one to six). Cementless revision shaft, type S.F., was replaced at the same time as the new revision cup in 20 patients. Press-fit fixation of the implant was achieved in ten cases, however in all cases it was felt that titanium fixation screws were required. In all patients, ground bone grafts were applied to the defects and to the space between the implant ribs. The surgical procedure was performed by five surgeons.

In the postoperative period, patients were followed at 1.5, three, six and 12 months, and annually thereafter. For confirmation of the results, we carefully evaluated and recorded the average Harris hip score (HHS; encompassing subjective and objective evaluation of hip dysfunctions). At every follow-up with the exception of the first, X-rays of the re-implanted joint were obtained in two views. Postoperative complications and the position of the implant and fixation screws (signs of

osteolysis around the cup and screws, stability of the implant and the DeLee radiolucent zones, or any potential signs of implant migration) were assessed, along with osteointegration of the implant and bone tissue remodelling around the implant and ribs. Density of the bone and peri-prosthetic space were manually assessed on computed tomography (CT) images (slice thickness 3 mm, reconstruction index 1 mm, 135 kV, 150 mA) in Hounsfield units.

Results

BMI increased from a pre-surgical mean value of 27.7 to 28.1. No peri-operative complications were noted; primary fixation of the implant with the use of additional fixation screws was always sufficient. One patient suffered transient femoral neuropraxia, which gradually resolved.

The average HHS increased from 39.8 to 85.3; excellent results were achieved in nine patients (29.0 %), good in 16 (51.6 %), fair in three (9.7 %) and poor in three patients (9.7 %).

Radiological images detected only one case of TC cup migration in the proximal direction in the area of the defective acetabulum, type 3B according to Paprosky, with osteolysis noted surrounding screws. One female patient refused any further surgical intervention with respect to her general ill health. In one obese female patient, we noted discontinuity of both proximal screws with no migration of the implant detected. According to X-ray evaluation, 25 hips had a well-fixed, bone-ingrown cup (Fig. 2) and five had a stable fibrous union in the middle and the distal third of the implant (radiolucent line within 2 mm in zone III according to DeLee). Periacetabular osteolysis was not detected on radiological images. Revisional femoral components showed good fixation with bone ingrowth; for non-reimplanted shafts no evidence of aseptic release was observed.

Fig. 2 **a** AP radiograph six years after surgery shows good signs of implant osteointegration. **b** Axial view

Fig. 3 **a** CT scan, frontal view, shows remodeling of bone tissue in the area between the implant ribs. **b** Transverse view

Ten patients additionally underwent pelvic CT provided signed, inform consent. Remodelling of bone tissue in the space between the implant ribs was proved in all cases (Fig. 3). There were no documented bone cysts, characteristic for aseptic loosening. After using autologous spongionoplasty, bone defects were filled and integrated in all patients that attended follow-up. In five patients, we detected fibrous union within 2 mm in the convexity of the cup as on X-ray images. Kaplan-Maier survivorship of the acetabular components was 94.2 % at 7.1 years (Fig. 4).

Discussion

The number of revision THA procedures performed is gradually increasing due to the decreasing age of patients receiving primary arthroplasty. The most frequently re-implanted component in our geographic area is the cup, partially due to the valgus position of the neck in the popular cemented Poldi endoprosthesis [9, 16]. In general, there is consensus that a loosened cemented implant should be replaced with a

cementless implant [21], the type and shape of which should always correspond to the peri-operative findings and quality of the bone tissue. These basic requirements were also followed in the construction of the TC revision oval cup. In our studies we have confirmed that only reliable primary implant fixation, its qualitative osteointegration and remodelling of surrounding bone tissue, leads to favourable function of the hip joint.

Reliable primary fixation during revision arthroplasty is significantly enhanced by the thorough removal of necrotic tissue. According to Götz, the implant surface should be in contact with the original bone stock to a level of at least 50 % [8]. The Paprosky classification can be used to guide the peri-operative procedure [15]. Standard cementless implants with an osteoactive surface can be used to maintain the anterior and posterior column of the acetabulum (1, 2A-B according to Paprosky). Beginning with type 2C, the proximal aspect of the acetabulum must be addressed by using a structural corticospongious graft with a spherical cementless cup [15], or by choosing an oblong revision cup corresponding to the shape of the defective acetabulum [12]. Type 3B is associated with a high risk of loosening the revision implant [2]. The optimum solution appears to be the augmented cemented implant (Burch-Schneider splint). We maintain a very reserved approach with respect to “jumbo cup” and “high hip centre” methods. According to Cameron, a “jumbo cup” may be implanted in cases in which the vertical dimension of the defective bone bed does not exceed the anteroposterior dimension by more than 1 cm [1]. In reviewing studies, the majority state that a “high hip centre” results in early loosening of the implant.

The introduction of oval-shaped cups into clinical practice in 1980 resulted in significant improvement in revision THA. The construction of these cups enabled less extensive bone resection, with restoration of the anatomical rotation centre. By using the S-ROM system, De Boer and Christie achieved a mean HHS value of 91 points an average of 4.5 years after re-implantation [5]. Chen et al. reported 96 % five-year survival of oblong cups in Paprosky defective acetabulum 2B, 2C and 3A [3]. Cameron did not note a single case of loosening and

Fig. 4 Kaplan-Maier survivorship of the acetabular components was 94.2 % at 7.1 years

achieved very good mid-term results with S-ROM [2]. In resolving large bone defects, very good results, including long-term results, were achieved in many European centres using Lang-Ovale Revisionspfane (L.O.R.). Koster and Willert reported a group of 109 hips with 98.1 % survival after eight years of follow-up [11, 12]. Civinini et al. described 53 patients with a mean HHS value of 79 after five to ten years from revision surgery [4]. In the Czech Republic, the most frequently implanted revision cup is the Walter oval–Medin oval, the construction of which is nearly identical with the L.O.R. [14]. The modification thereof lies in the osteoactive surface (titanium spray with a micro layer of hydroxyapatite). In a group of 78 patients with a mean follow-up of 63 months, Fousek and Vašek noted good osteointegration of the implant in 74 patients, with a mean HHS value of 82 points [6]. Landor et al. evaluated 16 years of experience with 267 revision surgeries and compared the survival of the L.O.R. cup with the Medin oval cup. The Kaplan–Maier survival curve showed a slight, but statistically significant, higher level of survival in the Czech-made cup [13].

Development of the type TC revision oblong cup began at the Beznoska company in March 2003, building on the success of the type SF spherical cementless cup [18]. Since 2009, the cup has enabled proximal fixation with fixed-angle screws. In an experimental study (pull-out test) using the Instron-3382 test machine in bovine cadaveric hips, we proved that this fixation is more rigid compared to using conventional screws [19]. High quality primary fixation of the implant produces optimal conditions for osteointegration. Our results showed gradual failure of bone fixation of individual conventional screws. Fixed-angle screws were not displaced from bone tissue, but were deformed. Hugate et al. achieved similar results in a biomechanical study of eight cadaveric human pelvic bones using standard spherical cementless press-fit cups [10]. In our group of the first 43 patients, we did not fix the cup using fixed-angle screws.

Objective evidence of the level of bone tissue remodelling around the implant is very difficult to obtain without revisional surgery. Fluoroscopy and digital radiography with the beam directed toward the ribs is confounded by summation with the pelvic and abdominal organs. A CT scan has a significantly higher degree of sensitivity. CT scanning minimizes artefacts around the metallic components; osteolytic areas around the acetabulum can be reliably evaluated and fibrous union can be distinguished from potential artefacts around the implant [7]. Sandgren et al. evaluated signs of periacetabular osteolysis in a group of 206 patients ten years after primary implantation of total hip replacement after using computed tomography and digital radiography. CT scans detected small or large osteolytic changes in 184 cases and radiography in 14 cases [17]. Detection of loosening of the hip arthroplasty replacement or revision hip implant may

prevent severe destruction of the acetabulum through early intervention.

In our opinion, the advantage of the TC cup in comparison with other types of implants is the possibility of spongioplastic application in the proximal part between the implant ribs. Bone remodelling in the setting of good primary cup fixation helps to reduce the bone tissue defect, improving conditions in the case of re-implantation.

In evaluating the mid-term results of a rather mixed group of 31 patients, our results are comparable to similar studies. Our results show ease of implantation, reliable primary fixation and documented signs of bone remodelling in the surrounding area.

References

1. Cameron HU (2001) Cavity-filling components: when round isn't right. *Orthopedics* 24(9):879–880
2. Cameron HU, Smula V (1999) Use of oblong socket in hip revision surgery. *Acta Chir Orthop Traumatol Cech* 66(1):7–9
3. Chen WM, Engh CA Jr, Hopper RH Jr, McAuley JP, Engh CA (2000) Acetabular revision with use of a bilobed component inserted without cement in patients who have acetabular bone-stock deficiency. *J Bone Joint Surg Am* 82(2):197–206
4. Civinini R, Capone A, Carulli C, Villano M, Gusso MI (2008) Acetabular revision using a cementless oblong cup: five to ten year results. *Int Orthop* 32(2):189–193
5. DeBoer DK, Christie MJ (1998) Reconstruction of the deficient acetabulum with an oblong prosthesis: three- to seven-year results. *J Arthroplasty* 13(6):674–680
6. Fousek J, Vašek P (2007) Oblong cup in the management of aseptic loosening of the acetabular component in total hip replacement. *Scand J Surg* 96(4):319–324
7. Garcia-Cimbrelo E, Tapia M, Martin-Hervas C (2007) Multislice computed tomography for evaluating acetabular defects in revision THA. *Clin Orthop Relat Res* 463:138–143
8. Götz C, Sippel C, Wendt G, Steinbeck J (2003) Limits in cementless hip revision total hip arthroplasty. Midterm experience with an oblong revision cup. *Z Orthop Ihre Grenzgeb* 141(2):182–189
9. Hart R, Rozkydal Z (1999) Longterm results of poldi hip replacement. *Acta Chir Orthop Traumatol Cech* 66(3):139–145
10. Hugate RR, Dickey ID, Chen WQ, Wood CM, Sim FH, Rock MG (2009) Fixed-angle screws vs standard screws in acetabular prosthesis fixation: a cadaveric biomechanical study. *J Arthroplasty* 24(5):806–814
11. Köster G, Radings S (2009) Revision of failed acetabular components utilizing a cementless oblong cup: an average 9-year follow-up study. *Arch Orthop Trauma Surg* 129(5):603–608
12. Köster G, Willert HG, Köhler HP, Döpkens K (1998) An oblong revision cup for large acetabular defects: design rationale and two- to seven-year follow-up. *J Arthroplasty* 13(5):559–569
13. Landor I, Vavřík P, Jahoda D, Pokorný D, Popelka S, Sosna A (2009) Oblong implants for revision total hip arthroplasty. *Acta Chir Orthop Traumatol Cech* 76(6):462–472
14. Landor I, Vavřík P, Sosna A, Bek J (2001) Total hip joint replacement with the Walter type of prosthesis: long-term results. *Acta Chir Orthop Traumatol Cech* 68(5):281–288

15. Paprosky WG, Perona PG, Lawrence JM (1994) Acetabular defect classification and surgical reconstruction in revision arthroplasty. *J Arthroplasty* 9(1):33–44
16. Rozkydal Z, Janíček P (2010) Poldi-Čech cemented femoral stem in total hip arthroplasty after 25 years. *Chir Orthop Traumatol Cech* 77(4):284–290
17. Sandgren B, Crafoord J, Garellick G, Carlsson L, Weidenhielm L, Olivecrona H (2013) Computed tomography vs. digital radiography assessment for detection of osteolysis in asymptomatic patients with uncemented cups: a proposal for a new classification system based on computer tomography. *J Arthroplasty* 28(9):1608–1613
18. Šťastný E, Trč T, Handl M, Frýdl J, Kopečný Z (2009) Cementless total hip replacement type S.F.: mid-term results. *Acta Chir Orthop Traumatol Cech* 76(6):487–494
19. Šťastný E, Trč T, Matěj D, Sekerka M (2012) Comparison of a primary TC revision oval cup fixation by using locking head and common screws. *Ortopedie* 6:211–214
20. Trč T, Šťastný E (2012) Oblong acetabular cup, type TC, for revision total hip arthroplasty. *Acta Chir Orthop Traumatol Cech* 79(6):506–511
21. Weber KI, Callaghan JJ, Goetz DD (1996) Revision of a failed cemented total hip prosthesis with insertion of an acetabular component without cement and a femoral component with cement. A five to eight-years follow-up study. *J Bone Joint Surg Am* 78(7):982–994