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Custom-made aMace acetabular implants in Paprosky type 3B defects: a case series of 5 patients with a follow-up of 6 to 10 years

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Total hip replacement revision surgery has become increasingly prevalent in today's society. This causes issues since, for each revision surgery, the quantity of accessible bone stock decreases and the complexity of surgery increases. As a result, readily available implants may not always address the patient's individual demands. For those patients, custom-made implants may be a feasible option.

This paper is a retrospective cohort-analysis of 5 patients who received an aMace custom-made acetabular implant produced by Materialise, placed by a single surgeon. At the time of writing, we conducted a cross-sectional cohort analysis of patients who received this custom-made acetabular implant between 2014 and 2016.

The mean follow-up time of 5 patients was 7.8 years (range: 6.3 – 10.6 years). All patients achieved excellent outcomes; there were no implant failures or known adverse events. Radiographic images demonstrate significant implant ingrowth with no signs of loosening. All patients expressed satisfaction and withheld no to minor complaints. Harris Hip Score (HHS) values ranged between 70.7 and 99.5, with a mean score of 85.6.

The aMace custom-made acetabular implant is a feasible option in patients with severe acetabular defects undergoing revision arthroplasty. At this moment, the primary issues are the cost of the cup and the reimbursement criteria.

Keywords: Revision arthroplasty, hip arthroplasty, Paprosky 3B defect, custom-made acetabular implants, aMace, Materialise, CTAC.

INTRODUCTION

Total hip replacement remains the gold standard for patients with end-stage hip joint osteoarthritis. The demand for this surgery is increasing annually, particularly in the category of multiple revised implants. Over the past decade, a tenfold increase in primary hip arthroplasties across European countries has been reported, accompanied by an annual revision burden of 12.9%, and there is no evidence of this trend plateauing.

While most patients benefit from readily available implants, some require specialized solutions due to multiple revision surgeries leading to acetabular bone loss. Custom-made implants, therefore, may be preferred. In this case series, five such implants were used between 2014 and 2016, with follow-up periods ranging from 6.3 to 10.6 years (mean 7.8 years).

MATERIALS AND METHODS

Study population

A retrospective analysis was conducted on five patients who underwent custom-made acetabular implantation between January 2014 and December 2016. Data were collected regarding implant survival, as well as complications (e.g. infection). The mean age at surgery was 57.6 years, with a male-to-female ratio of 2:3 (Table I). The primary diagnosis for all patients was aseptic loosening, accompanied by extensive bone loss. All patients had undergone prior acetabular revisions.

Patient eligibility was determined based on seven pre-established criteria by the Belgian Institute for Invalidity and Healthcare (RIZIV), using the Paprosky classification (cfr. Addendum). Additionally, eligibility assessment included conventional pelvic X-rays and CT-based 3D pelvic reconstructions.

Each patient was classified as Paprosky 3B, indicating significant bone defects that precluded the use of

standard acetabular reconstruction cups[2]. Detailed bone loss data are provided in Table II.

Implant characteristics

The aMace implants were designed in partnership with Mobelife. Materialise's aMace acetabular reconstruction cup, shaped as a custom triflange cup with flanges for the iliac, ischial, and pubic bones, is 3D-printed in a titanium alloy powder as a monoblock[3] (Figure 1). The cup's OSSIS mesh backing facilitates bony ingrowth, enhancing stability primarily supported by screws.

Materials and methods

Upon meeting eligibility criteria, Materialise proposed personalized acetabular implants using software to assess bone stock quality and generate a reconstruction model for optimal screw placement, crucial for osseous integration post-primary screw fixation (Figure 2 and 3). mplant propositions were tailored to each patient's unique needs and addressed screw conflicts with redundant options (Figure 4), leading to consensus on a preliminary model with a screw placement proposal (Figure 5). Generated models included templates detailing patient characteristics and proposed anatomical adjustments (Figure 6), while emphasizing biomechanics, osseous integration, and pull-out strength. Due to technical and patient-specific considerations, the proposed centre of rotation and cup details (inclination, anteversion, diameter) varied per case. Upon surgeon approval, a 3D implant, cup replica, hemipelvis model, and

Table I. — Patient characteristics.

	Age (years)	Sex	Laterality	Number of prior acetabular revisions	Follow up (years)	Cup poly size (mm)	Type of articulation
Patient 1	59	Male	Left	1	9,7	50	Low profile
Patient 2	49	Female	Right	1	10,6	50	Low profile
Patient 3	67	Female	Right	3	6,3	50	Dual mobility
Patient 4	51	Female	Left	1	6,3	50	Dual mobility
Patient 5	62	Male	Left	2	6,3	54	Low profile

Table II. — Detailed bone loss.

	Classification	Cranial region	Anterior column	Medial wall	Posterior column	Original anatomical acetabular rim	Joint center displacement
Patient 1	Left hemi-pelvis - Paprosky 3B	Extremely degraded	Degraded antero-superiorly and anteroinferiorly; bone (de) formation present	Severely degraded and partly deformed.	Severely degraded and deformed postero-superiorly and slightly degraded postero-inferiorly.	Fully deformed, and thus absent from at least nine to five o'clock.	Not assessable (no contralateral info), but likely more than 2cm
Patient 2	Right hemipel-vis- Paprosky 3B	Very degraded	Extremely degraded; very thin bony structures remaining especially inferior region. Almost discontinuous	Extensive bone loss; almost missing inferiorly	Very degraded. Very thin bony structures remaining. Almost discontinuous	Fully deformed, and thus absent from at least nine to five o'clock. .	Displacement of native hip joint (<2cm), in superior and medial direction
Patient 3	Right hemipel-vis - Paprosky 3B	Severely degraded	Extremely degraded; nearly missing	Severely degraded; fenestration present	Severely degraded	Fully deformed, and thus absent from at least nine to five o'clock.	-
Patient 4	Left hemi-pelvis - Paprosky 3B	Extremely degraded	Severely degraded; nearly missing	Moderately degraded	Severely degraded	Fully deformed, and thus absent from at least nine to five o'clock.	Displacement of the joint center is larger than 20mm (29mm)
Patient 5	Left hemi-pelvis - Paprosky 3B	Extremely degraded	Severely degraded	Severely degraded	Severely degraded	Fully deformed, and thus absent from at least nine to five o'clock.	Displacement of the joint center is larger than 20mm (36mm)

Fig. 1 — Example of Materialise aMace acetabular cup.

drill guides were created. The hemipelvis model aids bone removal with cut-outs matching the required areas, supported by a reference sheet specifying bone volume and removal areas. All surgeries were performed using a modified posterolateral approach by a single surgeon. The acetabulum was reamed using the 3D template, promoting bony ingrowth with bone grafts. After cup implantation and fixation, a liner was cemented into the pelvis. All patients were allowed immediate full weight-bearing postoperatively.

RESULTS

No implant failures or adverse events (e.g. instability, infections) have been reported to date. Radiographic images of all cases demonstrate strong implant ingrowth with no signs of loosening. Figures 7A-E show the pre-operative, direct post-operative and latest follow up radiographs.

All patients expressed satisfaction and withheld no to minor complaints. Harris Hip Score (HHS) values ranged between 70.7 and 99.5, with an average of 85.6. Two out of three HHS values lower than 90 were attributed to pathologies unrelated to the revision surgery.

Our experience

The aMace implant is valuable in treating severe acetabular defects during hip arthroplasty revisions. Key challenges involve achieving optimal exposure and precise implant placement. Minor adjustments were made in subsequent cases to improve fitting, motivating flexibility in the model's accuracy.

DISCUSSION

As the global population ages, primary hip arthroplasty numbers rise, leading to more revision surgeries1. Acetabular implant fixation may be extremely challenging in patients with extensive bone loss (Paprosky 3A/3B). Impaction bone grafting and other techniques are not always feasible. In the past, the only remaining option appeared to be a Girdlestone resection procedure, impairing these

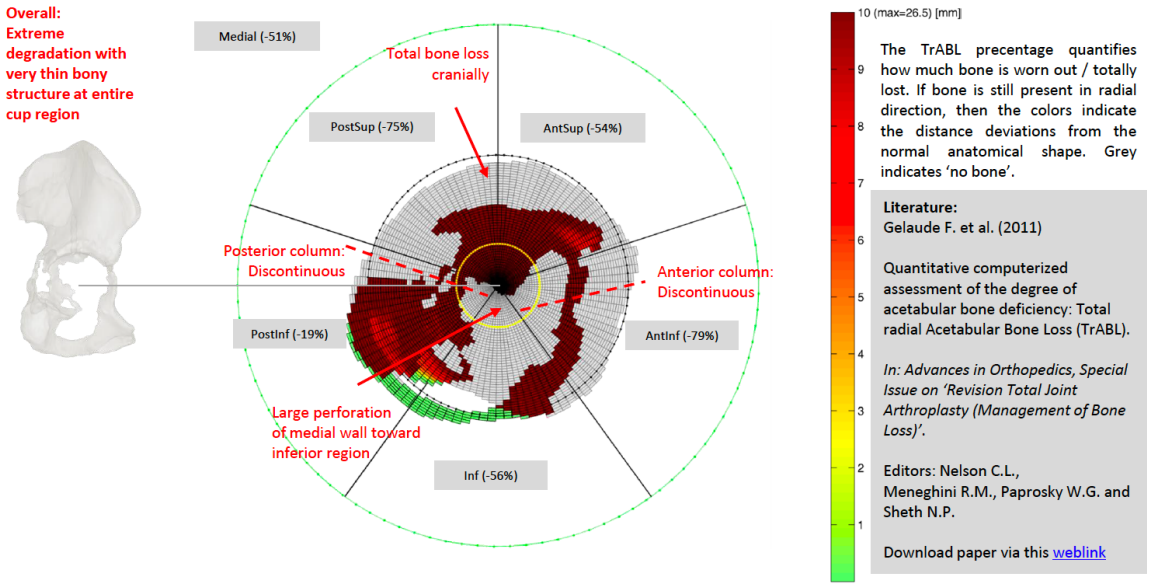

Fig. 2 — Acetabular bone loss.

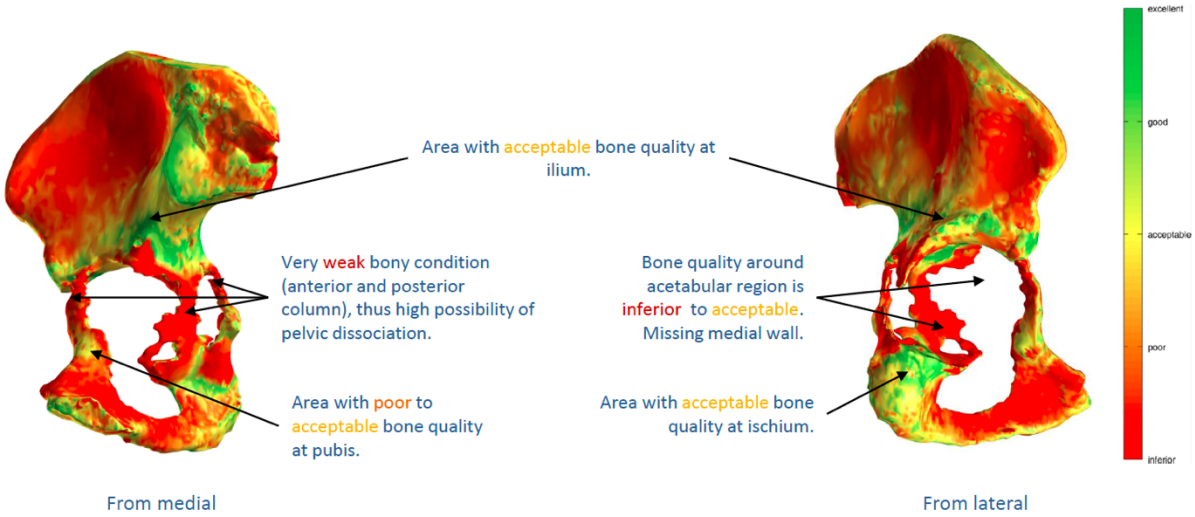

Fig. 3 — Bone quality.

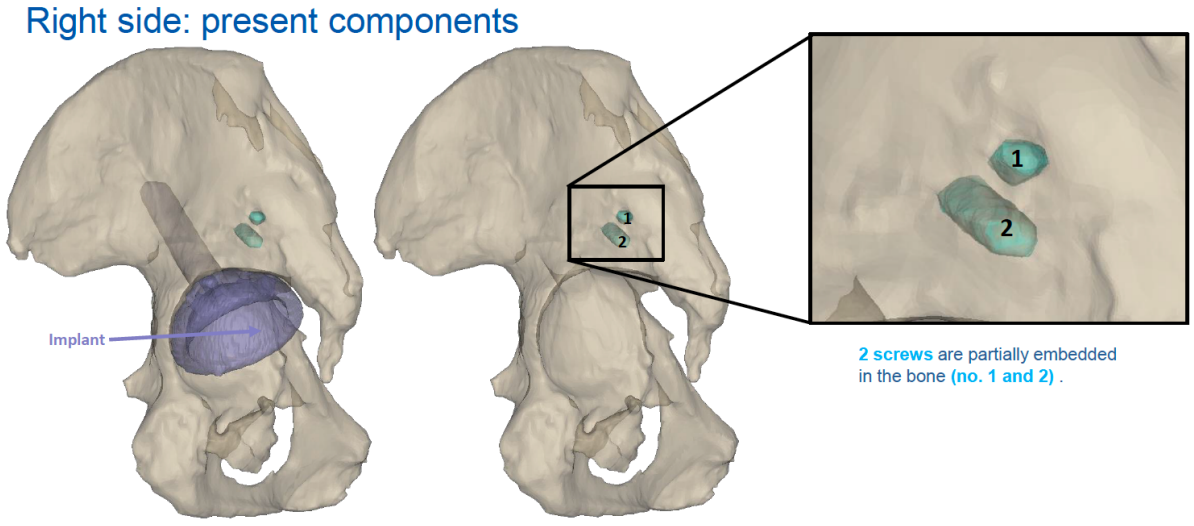

Fig. 4 — Preoperative determination of osseous integration of implanted components.

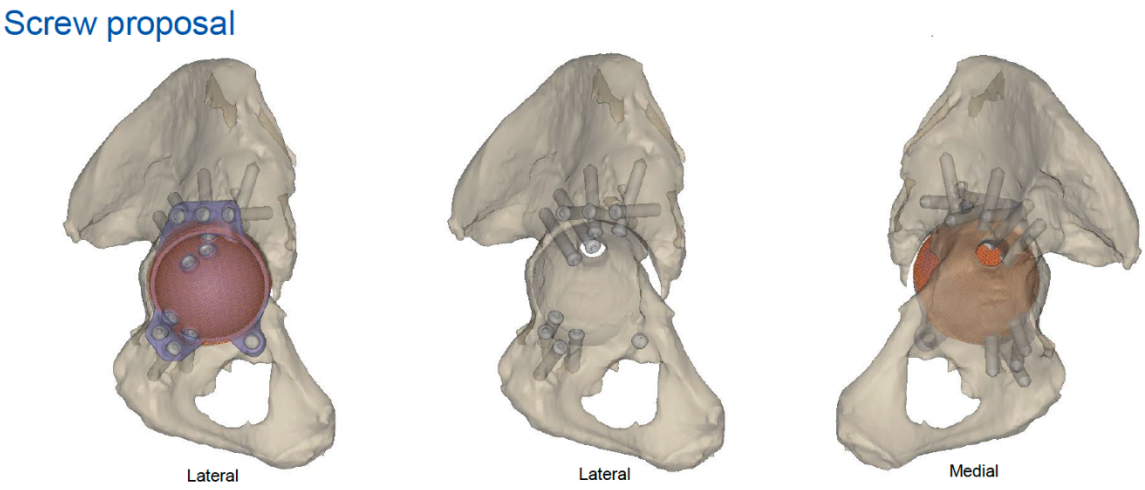

Fig. 5 — Screw placement proposal.

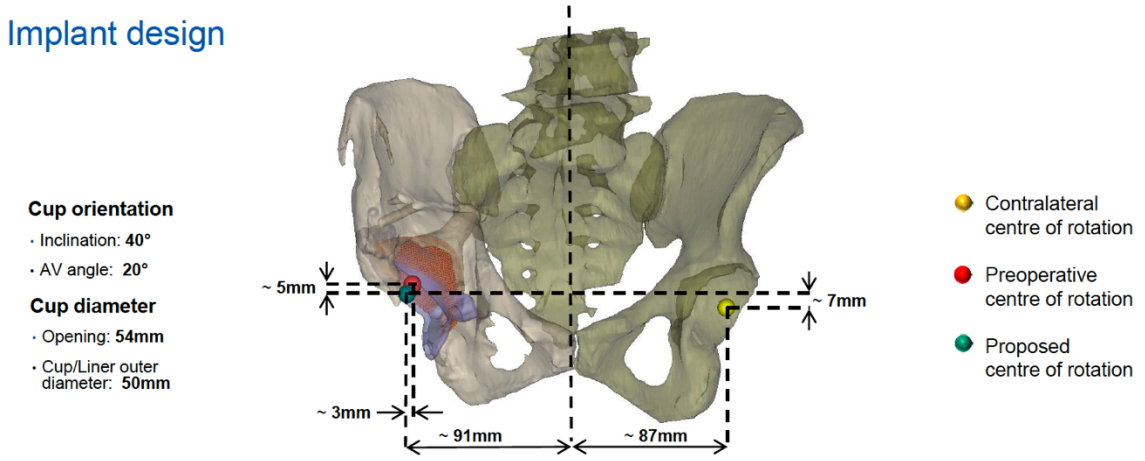

Fig. 6 — Implant design and biomechanics.

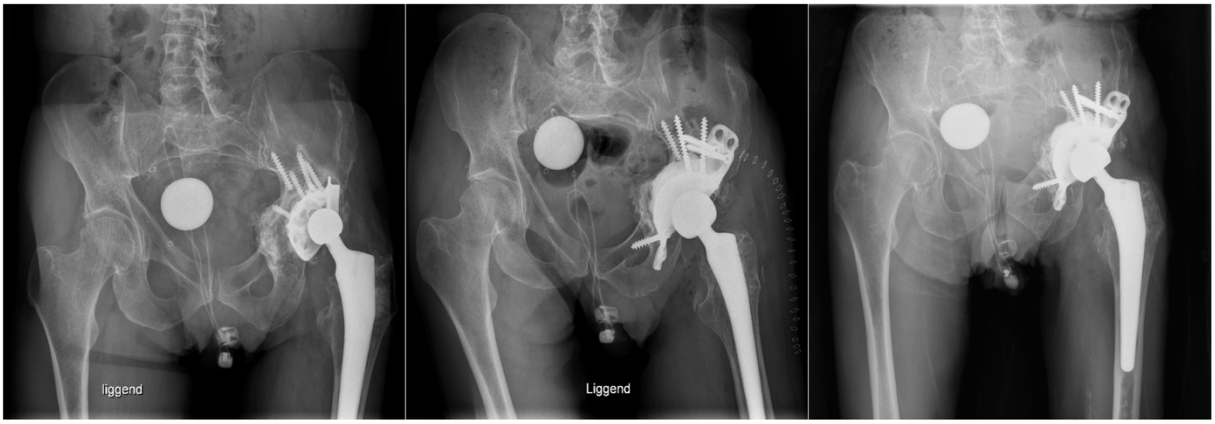

Fig. 7a — Pre-, postoperative and latest radiographs of patient 1, male, follow up 9.7 years.

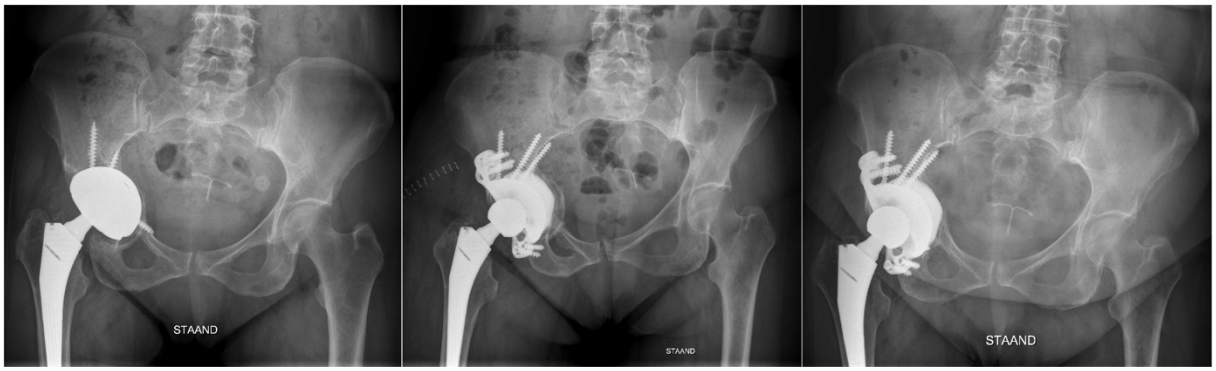

Fig. 7b — Pre-, postoperative and latest radiographs of patient 2, female, follow up 10.6 years.

Fig. 7c — Pre-, postoperative and latest radiographs of patient 3, female, follow up 6.3 years.

Fig. 7d — Pre-, postoperative and latest radiographs of patient 4, female, follow up 6.3 years.

Fig. 7e — Pre-, postoperative and latest radiographs of patient 1, male, follow up 6.3 years.

patients' subjective quality of life[4]. For over a decade, experience with custom-made triflanged cups has been growing, as evidenced by the publication of numerous, albeit smaller, case series.

The key drawback of these implants is the higher cost. While the production of such implants does place a strain on social security systems, in countries with universal health care, such as Belgium, this is a hurdle that can be overcome. Tack P et al. concluded in a comparative study that the Custom Three-flanged Acetabular Components (CTAC) and 3D-printed implant (aMace) are cost-effective in Belgium for Paprosky 3B defects[5]. For all patients, aMace resulted in a dominant, cost-saving strategy in Belgium compared to CTAC.

In 2020, Gruber et al. conducted a trial of nine patients who received an aMace type of CTAC with a mean follow up time of 12.2 months, where three cases (33.3%) reported complications, one of which led to a re-revision (11.1%)[6].

Our case series of five patients is one of the larger series published. All patients expressed satisfaction with no restrictions in their daily life.

The advantages of this technique include reconstructing complex acetabula, creating a stable primary construct and enabling rigid bony ingrowth. Achieving these requires technical expertise, proper exposure and bone grafting. Secondly, the cost of the aMace implant in Belgium is high. But until now, all aMace implants have been reimbursed by the Belgian health care system[5,7].

CONCLUSION

Our five-patient case series is one of the largest single-surgeon series published. All patients expressed satisfaction and withheld no to minor complaints. Post-operative radiographic control images demonstrate a stable construct with significant ingrowth and no signs of loosening.

Currently, the primary issues are the cost of the cup and the reimbursement criteria. We believe custom-made acetabular implants are a feasible option for patients with severe acetabular defects undergoing revision arthroplasty.

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Addendum

Eligibility criteria

1. The distance between the hip centre of rotation and the line connecting both superior obturator foramina is more than 3cm, as measured on a pelvic AP-view X-ray.
2. An implant of a standard cupula has already failed.
3. Advanced lysis, objectified by the absence of a normal "tear-drop" on a pelvic AP-view.
4. Advanced lysis, objectified by lesions of the ischiadic tuberosity on a pelvic AP-view.
5. Lesions of the medial wall, with interruption of the Kohler line (ilioischial line) on a pelvic AP-view.
6. Over 50% of the circumference of the acetabular rim is missing, as measured by 3D-reconstructions.
7. Pelvic discontinuity of the hemi-pelvis, as demonstrated on CT images and/or usable pelvic X-rays.

In order to be eligible for reimbursement, patients must meet a combination of criteria:

→ 1 or 2 in combination with 3 + 4 + 5 + 6

And/or

→ 7