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Utilisation des céramiques biphasées dans les pertes de substance osseuse acétabulaire sévères dans les reprises de prothèse totale de hanche (PTH) : étude de 22 cas avec suivi à long terme

VAUTRIN Matthias

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UNIVERSITE DE LAUSANNE – FACULTE DE BIOLOGIE ET DE MEDECINE

SERVICE D'ORTHOPEDIE ET DE TRAUMATOLOGIE  
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**Utilisation des céramiques biphasées dans les pertes de substance osseuse acétabulaire sévères dans les reprises de prothèse totale de hanche (PTH). Une étude à propos de 22 cas avec suivi à long terme.**

THESE

Préparée sous la direction du Docteur Frédéric Vauclair  
(avec la codirection du professeur Alain Farron)

et préparée à la Faculté de biologie et de médecine de l'Université de Lausanne pour  
l'obtention du grade de

DOCTEUR EN MEDECINE

Par

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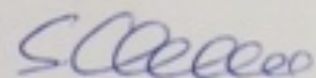
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avec suivi à long terme.***

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*pour Le Doyen  
de la Faculté de Biologie et de Médecine*



*Madame la Professeure Stephanie Clarke  
Directrice de l'Ecole doctorale*

# Phosphocalcium ceramics are efficient in the management of severe acetabular loss in revision hip arthroplasties. A 22 cases long-term follow-up study

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# Phosphocalcium ceramics are efficient in the management of severe acetabular loss in revision hip arthroplasties. A 22 cases long-term follow-up study

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**Abstract** Management of bone loss in revision total hip replacement remains a challenge. To eliminate any immunological or infectious problem and so to try to improve the long-term results obtained with allografts, the authors used synthetic ceramics as bone substitutes since 1995. We reviewed 13 of the patients of our study, we previously reported in 2005 (Schwartz and Bordei in *Eur J Orthop Surg Traumatol* 15: 191 2005), which was a prospective cohort of thirty-two cases of acetabular revision reconstruction, with a mean follow-up of 14.4 years yet (from 9 to 16 years). Clinical results were assessed according to Oxford scale and Postel and Merle d'Aubigne (PMA) scale. Since 2005, no specific complications were noted. The average PMA functional hip score was 14.9 (vs. 9.2 before revision) at follow-up over 9 years. Nine patients still alive in 2013 were seen again by a surgeon, which was not the operator, with a mean follow-up of 15.3 years: Their Oxford average score was 40.3. Radiological assessment affirmed a good integration of the substitutes in bone without any edging in all cases. A progressive invasion of the ceramics by bone can be seen on the X-ray. We conclude that about 15 years of average delay, which is a significant follow-up in orthopedic surgery, the outcomes without specific complications are satisfactory and allow one to go with these materials in total hip revision surgery.

**Keywords** Total hip arthroplasty revision surgery · Acetabular reconstruction · Bone loss · Ceramics

## Background

Aseptic loosening of the implants by progressive osteolysis secondary to wear particles is now well known [2–5]. Patients are for a long time slightly or not symptomatic as the process of bone advances, especially on the acetabular side. When the patient feels pain, the cup would be destabilized or have migrated and often a major bone loss would have occurred [6–11]. Hip arthroplasty revision surgery is then a challenging endeavor because of the extent of bone deficiency which can be of such severe magnitude as to compromise reconstruction. But in these situations, restoration of the bone stock may be necessary to provide a suitable support for the new prosthesis and to restore the anatomy in the end.

Good results have been reported over the world with the use of different allografts during arthroplasty revision and other orthopedic surgeries [12–14]. However, late failures (whose causes remain discussed) have been described, and an increasing interest in the use of ceramics has resulted in an augmentation of their use in clinical applications. Binding to the bone physicochemical has been proven in different papers [15–18].

In 1996, we began to use biphasic ceramics (hydroxylapatite and tricalciumphosphate) as bone substitutes in hip arthroplasty revision surgery.

## Materials and methods

Between October 1996 and March 2000, we performed this procedure in 32 hips in 32 patients [1]. Ten patients deceased since 2005. Twenty-two can be reviewed, so our series includes 13 women and 9 men; their mean age at operation was 68.2 years; and their age ranged from 45 to

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84. It was the first revision surgery on 18 cases and the second on 4 cases. For 13 cases the mean follow-up is a minimum of 9 years and a maximum of 16 years.

The acetabular bone deficiencies were assessed according to the American Academy of Orthopaedic Surgeons (AAOS) classification [19]. Segmental defects (AAOS I) were found in 12 cases, cavitory and defects (AAOS II) in 6 cases, and cavitory and segmental combined defects (AAOS III) (8 cases); in 6 cases of the hips, the deficiencies led to a pelvic discontinuity (AAOS IV).

The first calcium phosphate ceramic (Eurocer 400<sup>®</sup>) used as a bone substitute was presented in the form of granules composed of 45 % tricalcium-phosphate (TCP) and 55 % hydroxylapatite (HA), with a mean diameter of pores 400 μ and 60 % of volume total interconnected porosity. The second ceramic (Eurocer 200<sup>®</sup>) in different form blocks was made up of 65 % HA and 35 % TCP, with a mean diameter of pores 200 μ and 40 % of volume porosity. The characteristic of the second substitute was its mechanical resistance up to 20 MPa in vitro (*Eurocer 400 and Eurocer 200 +*, FH Orthopedics) Table 1. The porous and cubic irregular granules were used for cavity filling and less porous different shapes for providing the stability of reconstruction rings.

Surgical technique

The reconstructive surgical procedure began in every case with a complete removal of all the necrotic soft tissues adhering to the acetabulum remaining bone. The acetabulum was then regularized with hemispheric reamers and the possible bone puree recovered. We chose the acetabulum prosthesis depending on the local bone conditions:

- Cementless jumbo cup (from 60 to 74 mm diameter in 20 cases) when a primary stability can be obtained with a mandatory primary stability.
- Screwed support ring (from 58 to 62 mm in 12 cases) with an inferior anchorage hooks in all the cases of type AAOS III and AAOS IV. All bone defects over 1 cm<sup>3</sup> volume were filled with granules and/or from in all cases of acetabulum deficiencies. We should note that

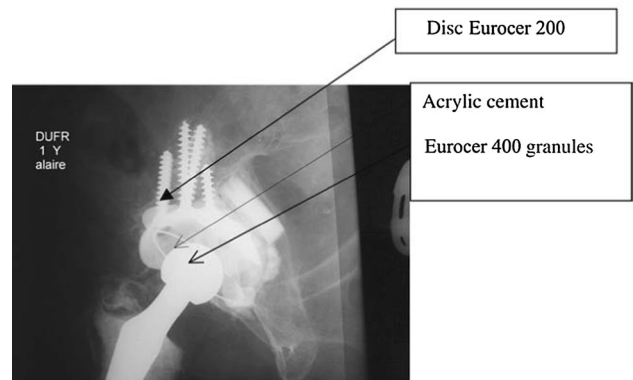
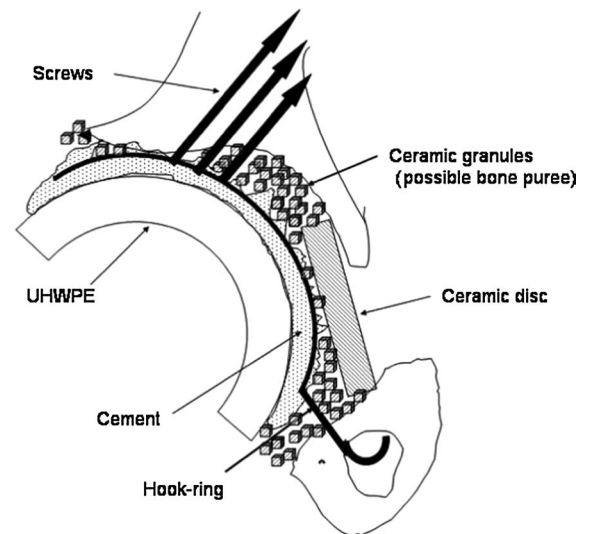


Fig. 1 Reconstruction in AAOS type IV cases

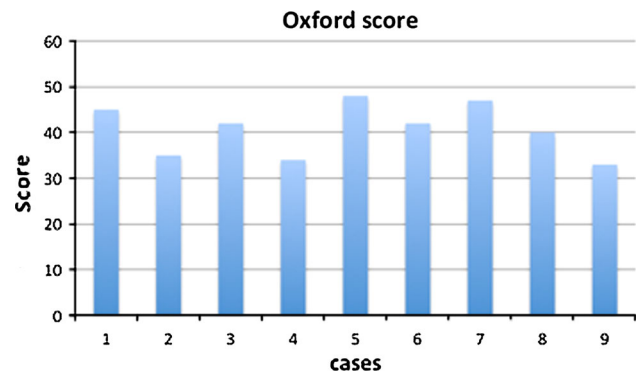


Fig. 2 Oxford average score of the nine alive patients

Table 1 Composition and characteristics of the ceramics

Ceramic	Eurocer 200+	Eurocer 400
Hydroxylapatite	65 ± 0.5 %	55 ± 0.5 %
Tricalciumphosphate	35 ± 0.5 %	45 ± 0.5 %
Total porosity	60 %	60–80 %
Pores diameter	150–300 μ	300–500 μ
Compressive strength	20 Mpa	

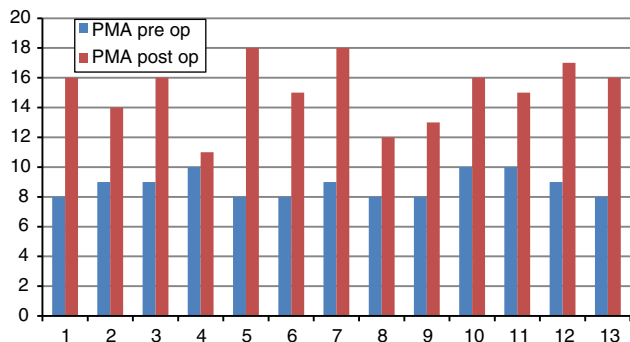
in AAOS IV cases, we made it with the best fitting possible, behind the cup if necessary; in some cases, when the medial wall or (and) the roof was absent, cups were screwed in the iliac wing (Fig. 1).

Bone-reaming remainders when existed were mixed with the granules. When support rings were used, the polyethylene socket was stuck to the ring with a 3 to 5-mm-thick cement layer, without entering more than 2–3 mm

between the granules or (and) blocks (Fig. 1). Partial weight bearing was allowed immediately and total weight bearing always after 6 weeks.

**Table 2** Mean results according to Postel-Merle d'Aubigne (PMA)

	Pain	Mobility	Stability	PMA score/18
Pre OP	1.7	4	3.5	9.2
Last review	5.7	4.5	4.7	14.9



**Fig. 3** Detail results at 9-year follow-up according to Postel-Merle d'Aubigne (PMA)

Clinical assessment was carried out on the latest follow-up, all over 9 years in 13 cases, according to the PMA scale (quantified from 0 up to 18: a maximum of six for no pain, a maximum or six for normal mobility and a maximum of six for normal walking and stability). A surgeon, who was not the patient operator, examined 9 alive patients in 2013 with a follow-up over 15 years and ranked with the new Oxford score [20]. It is a simple score with 12 questions only, clear and precise, all in five levels of answers. This method, when summed, produces overall scores running from 0 to 48 with 48 being the best outcome (Fig. 2).

The evaluation was completed with different radiographic studies: Edge around of the acetabular component was researched, and interface between ceramics and bone and changes in aspect of the ceramic and (or) the recipient bone was studied.

**Results**

Further revisions: No patient needed an additional revision since the review of 2005.

Functional evaluation: The average PMA global score grew from 9.2 preoperative (mean pain score 1.7, mean

**Table 3** Oxford score of 9 patients alive with follow-up of 15.3 years

Name	Questions Vorname	1	2	3	4	5	6	7	8	9	10	11	12	Total
HAR	JP	4	4	4	4	4	4	2	4	4	4	3	4	<b>45</b>
STO	J	3	4	4	3	2	2	2	4	3	3	2	3	<b>35</b>
FOH	J	4	4	3	4	1	4	3	4	4	4	3	4	<b>42</b>
GRA	M	2	4	2	3	4	3	2	3	3	3	3	3	<b>35</b>
GUI	M	4	4	4	4	4	4	4	4	4	4	4	4	<b>48</b>
HAE	I	3	4	4	4	4	3	2	4	2	3	4	4	<b>41</b>
JOA	M	4	4	3	3	4	2	3	4	3	4	3	3	<b>40</b>
MAR	I	4	4	4	4	4	4	4	4	3	4	4	4	<b>47</b>
MIC	L	4	4	4	0	4	0	0	2	4	4	0	4	<b>30</b>

**Questions**

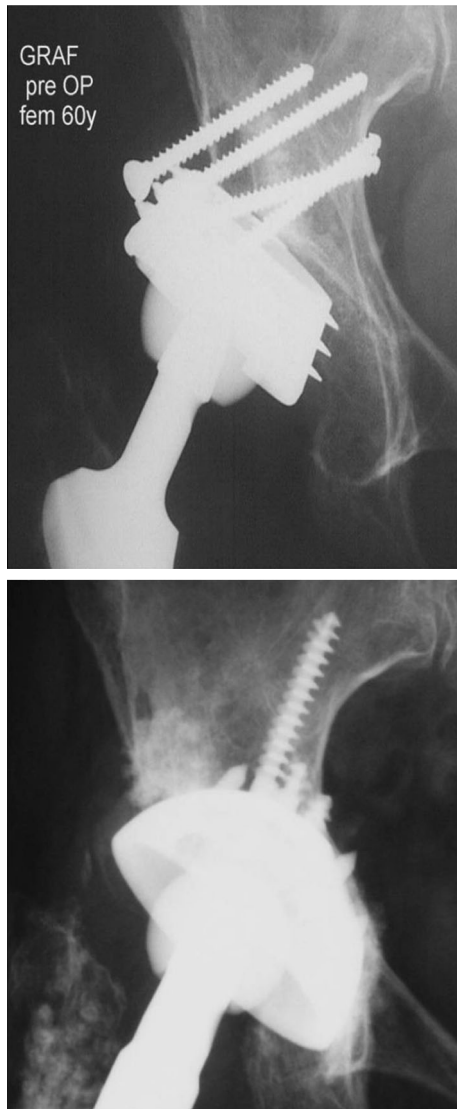
1. Usual pain
2. Pain at night
3. Severe pain (shooting, stabbing...) from affected hip
4. Limp when walking
5. How long able to walk before severe pain
6. Climb a flight of stairs
7. Able to put a pair of socks
8. Pain when stand up from a chair after a meal
9. Trouble getting in and out a car or public transportation
10. Trouble with washing and drying yourself
11. Household shopping on your own?
12. Pain interfered with usual work?



mobility score 4 and mean walking and stability score 3.5) up to 14.9 at the longtime postoperative follow-up (pain 5.7, mobility 4, 5 and walking and stability 4.7) Table 2 and Fig. 3.

The range of movement was improved in the majority of the series. Walking ability was globally improved too, but lesser because of frequent muscle weakness secondary to age of the patients. Crutch or walking stick remained necessary in 5 of the cases. Hip pain was nearly or totally alleviated.

This Oxford score focuses on stability and mobility more than pain as PMA. The average score of the 9 patients alive was at last review 40, 33 (from 30 to 48), which may indicate satisfactory joint function and may not require any formal treatment Fig. 2 and Table 3.

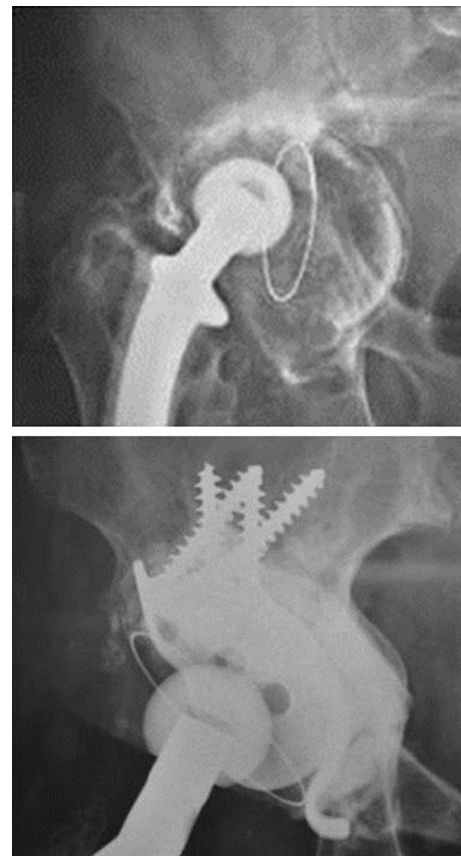


**Fig. 4** AAOS I before OP and at 9 years

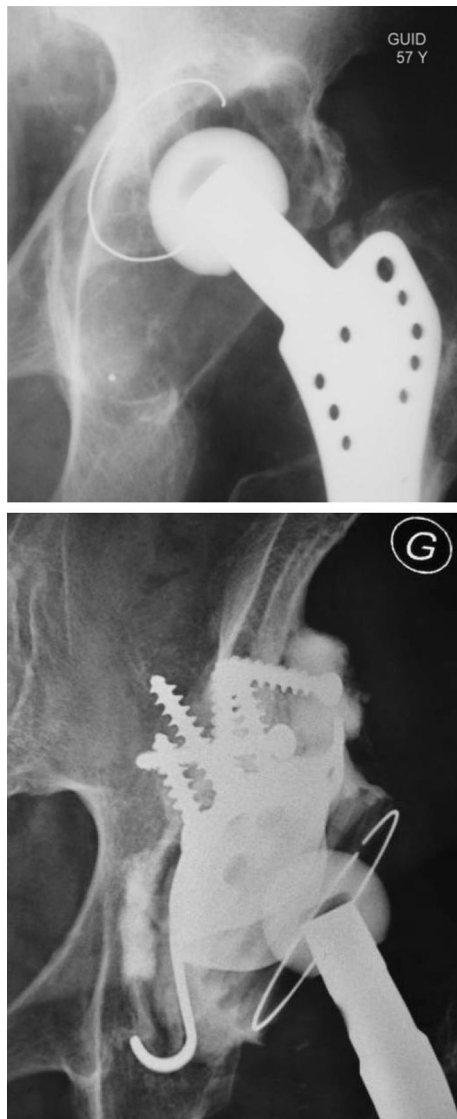
**Radiological evaluation:** There are no radiolucent borders around the cups between ceramics and bone. No measurable migration was noted. The ceramic blocks are very slowly and gradually reabsorbed on their edges year after year. They are always integrated in a composite with new formed bone Figs. 4, 5 and 6.

## Discussion

Biphasic phosphocalcium ceramics used as bone substitutes is very challenging in revision THA. Our study confirms that pain who decreased after surgery remains absent or moderate at longtime follow-up; that stability and mobility are slowly decreasing with age after a mean follow-up of 14.4 years. Evaluation of bone graft efficient and incorporation in hip total arthroplasty revision is classically based on radiological criteria such as migration analysis, development of radiolucency as well as on clinical criteria liable to the preoperative condition. In our series, the radiographic analysis showed the bone integration of biphasic ceramics to be total without any liseret between substitute and receiver bones. As this X-ray opaque material close to the recipient bone is probably a new formed

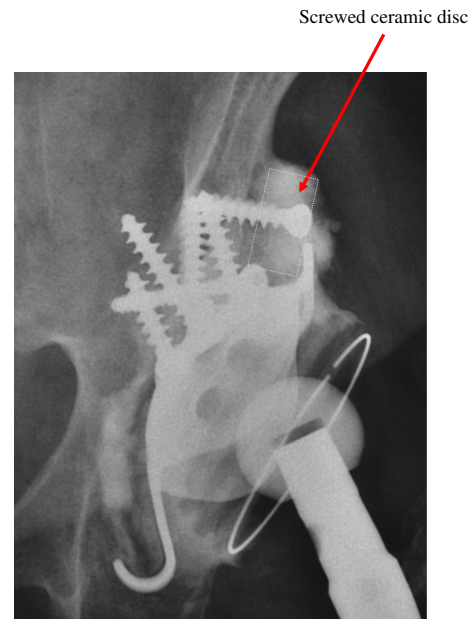


**Fig. 5** AAOS IV cases before OP and after 15 years



**Fig. 6** AAOS III cases before OP and at 16 years

bone which creeps between the granules and the blocks and sticks them to the recipient bone, it is difficult to have a precise idea only by means of the X-ray. We did not get the opportunity to have a histological study in absence of hip re-revision but in other sites had been proved [21, 22]. The granules are completely integrated in a ceramic–bone composite as it can be seen in every other implantation site in the skeleton. Biphasic substitutes are faster integrated than more compact forms. The early loading is certainly a positive element in this transformation so that a comparative papers could not be founded in the literature [23, 24]; but the results presented in this study are at the most comparable to the ones of non-structural allograft and uncemented cups with shorter follow-up, and if using allograft in reconstruction surgery shows good results with



**Fig. 7** Details of ceramic and bone binding after 16 years

short follow-up, they are less good with a mean follow-up and worst at long term (40 % of good results after 15 years of follow-up) (Fig. 7) [25–27].

The reason seems to be that when using synthetic ceramics as bone substitutes, there are some advantages: there is no immune reaction and so late resumption as it has been described with allografts. There is no risk of a viral or other contagious disease transmission because of the synthetic fabrication of the bone substitutes. This study asserts the advantages, safety and efficiency of the ceramics used in management of acetabular bone loss in revision total hip arthroplasty for loosening with a follow-up of more than 9 years.

**Conflict of interest** Dr. Schwartz reports other from null, outside the submitted work. Dr. Vautrin has nothing to disclose.

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