# Improving Outcomes In Cranioplasty - Clinical Results From 670 Patients Treated With OSSDSIGN® Cranial PSI

**Abstract**

Reconstruction of cranial defects can be a complex surgical procedure associated with an underestimated morbidity. This report describes the outcome of 670 cranioplasties using OSSDSIGN Cranial PSI, a patient-specific implant made from a calcium phosphate material reinforced with 3D printed titanium. All data was collected as part of post-market surveillance following introduction of the product in Europe, US and selected Asian markets in compliance with MEDDEV 2.7/1 rev.4 and MDR 2017/745. At an median follow up time of 17 months (range, 0-58 months) 32 implants (4.8%) had been explanted; whereof 16 (2.4%) of the implants were explanted due to early postoperative infections, 7 (1.0%) due to persistent wound dehiscence, 1 (0.1%) due to unsatisfactory aesthetical outcome and 8 (1.2%) due to other reasons, such as tumor recurrence.

Histological analysis of several implants explanted ≥ 9 months following surgery revealed bony integration between the implant and the native bone, as well as new bone formation within and around the remaining calcium phosphate material.

## Introduction

Cranioplasty is sometimes perceived as a straightforward procedure but literature confirms the opposite. Reconstruction of the cranium, especially involving large cranial defects, has high morbidity, regardless of the choice of reconstructive material. Autologous bone flaps have been the gold standard for a long time but rates of bone resorption and infection are high[1,2]. Use of inert alloplastic materials such as titanium, PEEK or PMMA, tailored to the patients defect anatomy can be used but these materials may be less than optimal as they seem to be linked to high rates of implant exposure, infection and ultimately implant removal[3,4]. Known risk factors of implant failure include irradiation, previous cranioplasty failures, thin and fragile soft tissue, exposed sinus cavities, age, and previous infections[5].

OSSDSIGN® Cranial PSI is the only patient-specific cranial implant that combines mechanical performance with long-term bone integration and remodelling. The implant consists of a 3D printed medical grade titanium mesh skeleton, encased in a calcium phosphate material with clinical and pre-clinical evidence of bone regenerative characteristics. OSSDSIGN® Cranial PSI is designed to be used for non-load bearing applications in patients where cranial growth is complete, and for use with an intact dura with or without duraplasty. The device is custom-made to fit each patient-specific cranial defect.

To date (July 2019), a total of 684 devices have been delivered to 90 European hospitals, 9 Asian hospitals and 29 hospitals in the USA.

## Materials and methods

Post-market surveillance data collection as part of regulatory requirements has been continuously performed by OssDsign in compliance with MEDDEV 2.7/1 rev.4 and MDR 2017/745. Specific patient-related information, such as age, sex and underlying pathology is not applicable, as this is not revealed during the normal implant ordering process. This data presents the outcome of 670 cases of cranial reconstruction using OSSDSIGN® Cranial PSI. 14 of the 684 devices originally

**TABLE 1.**

| Device size (cm²) | Number of devices (%) |
|---|---|
| ≤ 50 | 128 (19) |
| 51-100 | 139 (21) |
| 101-150 | 247 (37) |
| 151-200 | 141 (21) |
| 201-250* | 15 (2) |
| *Total* | *670 (100)* |

***Size distribution of OSSDSIGN® Cranial PSI in clinical use.***
**Devices shipped only to Europe. Cleared in Europe and Asia up to device size of 300 cm²*

ordered were not implanted for patient-specific reasons, none of which were device-related.
Of the 684 OSSDSIGN® Cranial devices originally delivered, 80% (550/684) were ordered by university hospitals with a high-level trauma unit (Table 2).

**TABLE 2.**

| Hospital type | Number of hospitals |
|---|---|
| University Hospital | 87 |
| General Hospital | 35 |
| Army Hospital | 1 |
| Veteran Hospital | 1 |
| Private Hospital | 4 |
| *Total* | *128* |

***Hospital systems using OSSDSIGN® Cranial to date (July 2019).***

One patient experienced a tumor recurrence 31 months following reconstructive surgery. This allowed for explantation of the implant and subsequent preparation of histological samples for analysis of bone formation.

## Results

As per July 2019, a total of 670 OSSDSIGN® Cranial PSI devices had been successfully implanted in US, European and Asian patients. At a median follow up time of 17 months (range 0-58 months) 32 implants (4.8%) had been explanted; whereof 16 (2.4%) of the implants were explanted due to early postoperative infections, 3 (0.4%) due to tumor recurrence, 7 (1.0%) due to persistent wound dehiscence, 3 (0.4%) due to early postoperative hematomas, 1 (0.1%) due to a non-device related dura rift post-op, 1 (0.1%) due to progression of autologous bone flap resorption and 1 (0.1%) due to unsatisfactory aesthetical outcome. (Table 3). None of the explantations were performed due to complications that were determined to be device related by the operating surgeon. Peer-reviewed data from a subpopulation of the material has shown similar figures in terms of device explantation due to infection[6].

Histological analysis of one retrieved implant (Figure 1-2) showed that the calcium phosphate was partly transformed

**TABLE 3.**

| Primary cause of explantation | Number of patients (%) |
|---|---|
| Infection (Early post-op) | 16 (2.4) |
| Tumor Recurrence | 3 (0.4) |
| Persistant Wound Dehiscence | 7 (1.0) |
| Hematoma (Early post-op) | 3 (0.4) |
| Non-device Related Dura Rift | 1 (0.1) |
| ABF Resorption | 1 (0.1) |
| Aesthetic | 1 (0.1) |

***Reasons for explantation of OSSDSIGN® Cranial PSI.***

into new, well-vascularised osteonal bone after 31 months, indicating that the triphasic calcium phopsphate composition has osteoconductive properties and that new bone growth can bridge between the ceramic tiles. This is consistent with earlier published data on use of the exact same calcium phosphate composition for cranial reconstruction[6,7,8]. The regenerative features of the material has also been confirmed in several preclinical studies.

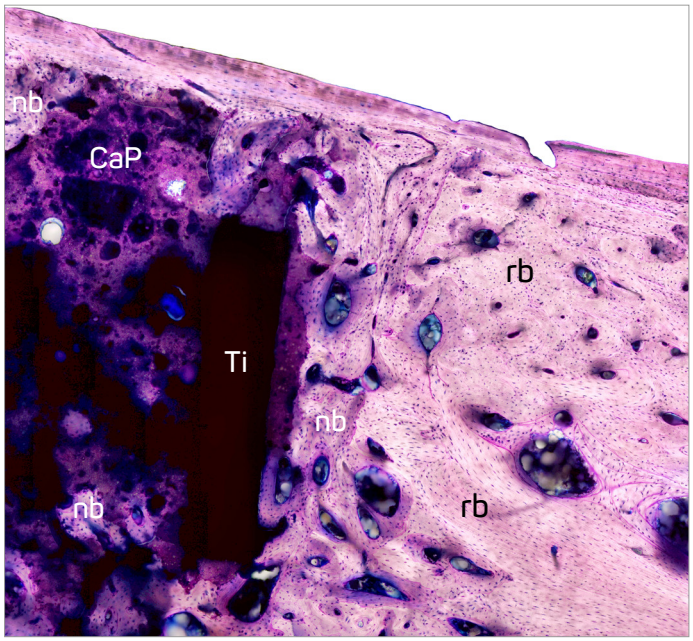


***Figure 1. Histological evidence of bone formation at 31 months post implantation.*** *Paragon stained sectioning of OSSDSIGN® Cranial PSI shows bony integration between the implant and the recipient bone (rb) as well as new bone formation (nb) within, and around the remaining calcium phosphate material (CaP) and supporting titanium structure (Ti).*

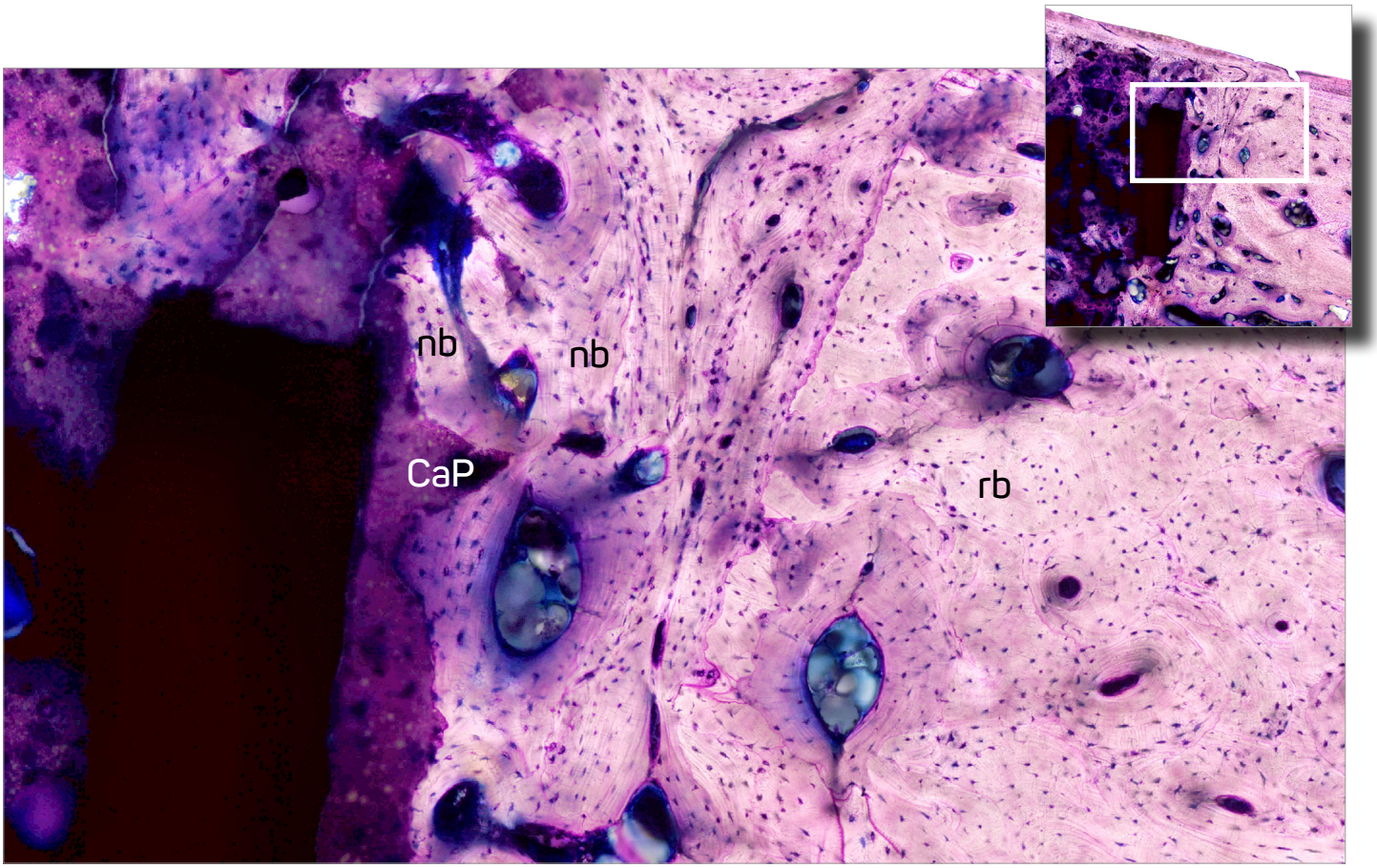


***Figure 2. Magnification of interface between recipient bone and OSSDSIGN® Cranial PSI following 31 months of implantation.*** *The magnified picture clearly shows the viable new bone (nb) growing in and around the reminants of the triphasic calcium phosphate material (CaP) of OSSDSIGN® Cranial PSI. The interface between new bone and recipient bone (rb) shows complete integration of the implant.*

A 52-week preclinical implantation study in a sheep model revealed the same pattern of host bone integration of the implant along with new bone formation in and around the calcum phosphate material[9].

In conclusion, OSSDSIGN® Cranial PSI has shown exceptional performance with an infection rate warranting implant removal of 2.4% in a patient population of 670 individuals at a median follow up time of 17 months

The bone-regenerative capacity of the calcium phosphate material has been substantiated in preclinical studies and is supported by clinical experiences in multiple cases.

**References**

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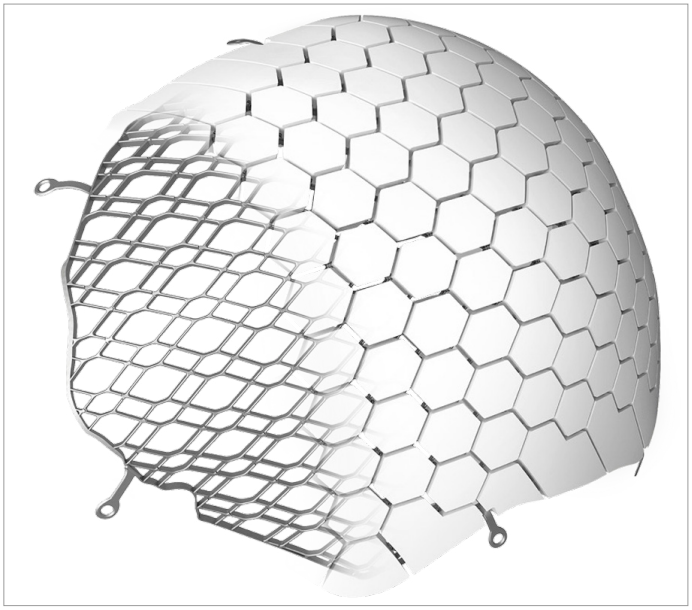
**About OSSDSIGN Cranial PSI**

OSSDSIGN Cranial is a patient-specific implant based on a biocompatible calcium phosphate composition with a strong titanium skeleton embedded in the core of its ceramic tiles.

OSSDSIGN Cranial PSI is intended for the reconstruction of cranial defects. It is indicated for non-load bearing applications for patients in whom cranial growth is complete, and for use with an intact dura, with our without duraplasty. Always read instructions for use which accompany the product for indications, contraindications, warnings and precautions.

**About OssDsign**

OssDsign is an innovator, designer and manufacturer of personalized bone replacement technology for cranial repair. We are surgeons, scientist and engineers - committed to improving outcomes in cranioplasty. For more information visit **ossdsign.com**.



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