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Short-term Outcomes of Impaction Bone Grafting Technique with a Collared Fully Hydroxyapatite-Coated Stem in Revision Total Hip Arthroplasty: A Case Series

Takamitsu Sato[1], Junichi Nakamura[1], Kazuhiro Oinuma[2], Yoko Miura[2], Hideaki Shiratsuchi[2], Seiji Ohtori[1]

Learning Point of the Article:

The combination of the Impaction Bone Grafting technique and a collared fully hydroxyapatite-coated cementless stem provides excellent early stability and reliable biological fixation in revision total hip arthroplasty with femoral bone defects.

Abstract

Introduction: Impaction bone grafting (IBG) with cemented stems in revision total hip arthroplasty (THA) is a well-established method, but reports using cementless stems are scarce. The purpose of this study is to report short-term outcomes of six revision THAs using the IBG technique with a collared fully hydroxyapatite (HA)-coated stem.

Materials and Methods: From 2014 to 2021, six joints (median age 64.3 years; median follow-up 4.5 years) were revised for aseptic loosening (n = 5) or septic loosening (n = 1). All cases used the IBG technique with a collared fully HA-coated stem (CORAIL or UNIVERSIA). Full weight-bearing was allowed post-operative day 1. Outcomes included the Japanese Orthopedic Association Score, stem subsidence, and radiographic remodeling.

Results: Median surgical time was 127 min; blood loss was 855 mL. No complications (infection, polyethylene wear, loosening, or dislocation) occurred. The JOA score improved from 63 (preoperatively) to 95 (final follow-up). Median stem subsidence was 1.4 mm (1–3 mm), with no case >5 mm. Radiographs showed no radiolucent lines and remodeling in all cases. Computed tomography (CT) images of one case confirmed bone ingrowth between the stem and the compressed allograft.

Conclusion: Short-term outcomes of revision THA with IBG using a collared fully HA-coated stem are favorable. This technique, supported by radiographic and CT evidence of bone ingrowth, is a useful and effective treatment option for femoral component revision.

Keywords: Impaction bone grafting, collared fully hydroxyapatite-coated stem, revision total hip arthroplasty

Introduction

Since the development in 1987 of the impaction bone grafting (IBG) technique using allograft bone to fill bone defects with the Exeter stem [1], many short-term and long-term outcomes of revision total hip arthroplasty (THA) using the IBG technique with a cemented stem have been reported [2,3,4,5]. Gie et al. in 1993 first reported good outcomes in 56 cases over 18–49 months [1]. Subsequently, Lamberton et al. performed revision THA using IBG in 540 joints, reporting a loosening-related re-revision rate of 2% at an average follow-up of 6.7 years [5].

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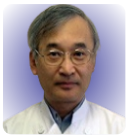
Author's Photo Gallery


Dr. Takamitsu Sato


Dr. Nakamura Junichi


Dr. Oinuma Kazuhiro


Dr. Yoko Miura


Dr. Hideaki Shiratsuchi


Dr. Ohtori Seiji

[1]Department of Orthopedic Surgery, Graduate School of Medicine, Chiba University, Chiba, Japan,
[2]Department of Orthopedic Surgery, Funabashi Orthopedic Hospital, Funabashi, Japan.

Address of Correspondence:
Dr. Junichi Nakamura,
Department of Orthopedic Surgery, Graduate School of Medicine, Chiba University, Chiba - 260-0856, Japan.
E-mail: njonedr@chiba-u.jp

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Wilson et al. performed revision THA on 705 joints, reporting a loosening-related re-revision rate of 1.2% at an average post-operative follow-up of 14.7 years [3]. Thus, revision THA using IBG with cemented systems has been reported to have good long-term outcomes in many cases. Long-term outcomes of IBG with a cementless cup on acetabular revision have also been reported [6,7]. However, few reports exist on revision THA using the IBG technique with a cementless stem. We have used a surgical technique using the combination of IBG and a collared fully hydroxyapatite (HA)-coated stem for revision THA [8]. The purpose of this study is to report the good short-term outcomes of six cases of revision THA using IBG with the cementless stem (collared fully HA-coated stem).

Methods and Materials

This study was approved by the Institutional Review Board of Funabashi Orthopedic Hospital (Approval Number: 2025007; Date of Approval: March 27, 2025). All procedures were performed in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from all individual participants included in the study.

From December 2014 to March 2021, six cases (three males and three females) involving six joints were revised using IBG with a collared fully HA-coated stem. The median age was 64.3 years (47–78 years), and the median follow-up period was 4.5 years (3.1–9.5 years). The reasons for revision surgery were aseptic loosening in 5 joints and delayed septic loosening in 1 joint. The bone defect level at the time of revision was classified according to Paprosky classification [9] as Type I in 1 joint, Type II in 4 joints, and Type IIIa in 1 joint. The surgeries were all performed using the direct anterior approach (DAA). The stems used were collared fully HA-coated stems CORAIL stem (CORAIL, Depuy Synthes, Warsaw, Indiana) in 3 joints and UNIVERSIA stem (UNIVERSIA, Teijin Healthforce, Okayama, Japan) in 3 joints.

Surgical data includes operation time, blood loss, length of hospital stay, and complications. Complications included intraoperative fractures, symptomatic pulmonary embolism, aseptic loosening, septic loosening, dislocation, and post-operative fractures. As a patient-reported outcome measure, the Japanese Orthopedic Association Hip Score (JOA Score) was used to evaluate hip condition preoperatively and at the final follow-up. The JOA hip score is a clinician-assessed, joint-specific outcome measure in which pain (40 points), range of motion (20 points), gait and walking ability (20 points), and activities of daily living (20 points) are summed to a maximum of 100 points per hip, with higher scores indicating better hip function. Radiographic review examined the length of stem subsidence and the presence of bone graft remodeling. Stem subsidence of 5 mm or more was evaluated as loosening. Remodeling was determined by the presence of spot welds on X-ray images.

Surgical technique

All revision surgeries were performed by a single senior author (KO) using a DAA to the hip. In December 2014, KO invented a surgical technique using the combination of IBG and a cementless collared fully HA-coated stem (Fig. 1). Two types of stems were utilized: CORAIL and UNIVERSIA. The IBG technique involves filling the medullary cavity from which the stem was removed with morselized allograft bone and compressing it with a broach. This process is repeated until a

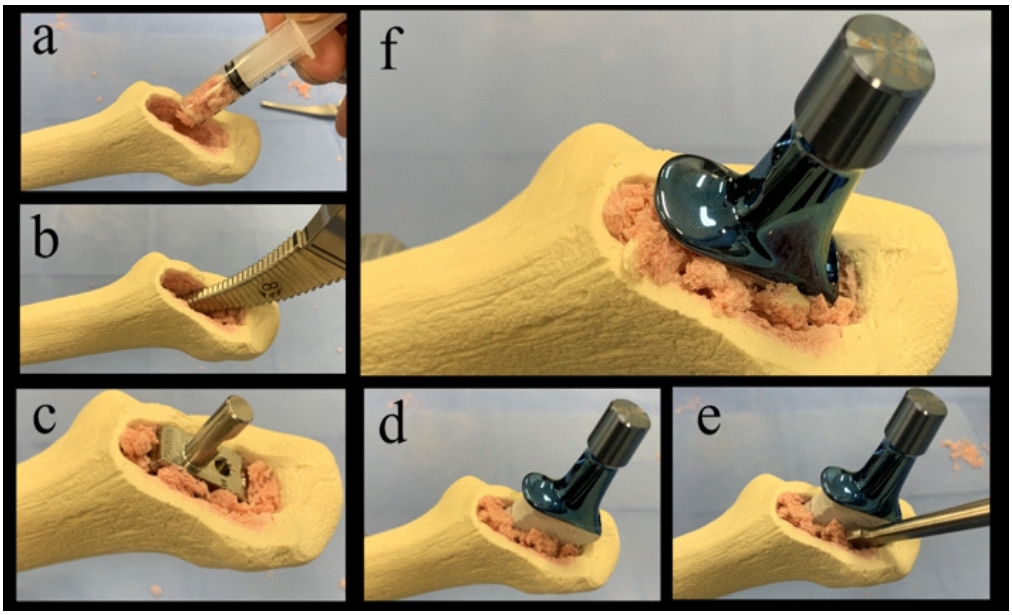

Figure 1: Demonstration of surgical technique using the combination of impaction bone grafting and a collared fully hydroxyapatite-coated stem. The bone grafting procedure involves the following steps: After removing the old stem, morselized allograft bone is packed into the intramedullary canal using a syringe (a), compressed through broaching (b), and the stem size is determined after confirming sufficient fixation (c). The new stem is manually inserted, and the grafted bone around the stem is impacted (d). Additional bone is packed around the stem (e), and the stem is driven in with bulk bone grafting at the calcar to complete the procedure (f).

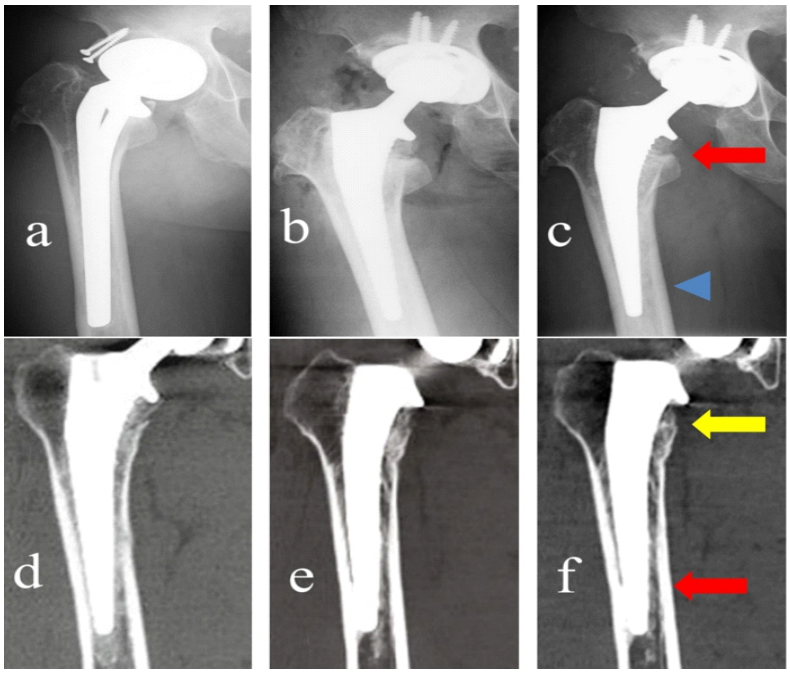

Figure 2: X-ray and computed tomography (CT) images in Case 1. (a) 10 years post-operative X-ray. (b) X-ray after revision surgery. (c) X-ray eight and a half years postoperatively. The allograft bone at the greater trochanter had integrated, making the boundary with the host bone indistinct (red arrow). Cortical hypertrophy at the distal stem had not progressed (blue arrowhead). (d) CT images taken 3 months post-surgery. (e) CT images taken 2 years post-surgery. (f) CT images taken 5 years post-surgery revealed remodeling of the bony mass in the calcar region (yellow arrow) and remodeling and bone growth in the allograft cancellous bone layer around the stem (red arrow).

sufficiently compressed cancellous bone layer is formed to allow insertion of an undersized stem, one size smaller than the original stem. The collared fully HA-coated stem is then manually inserted, and additional bone graft is added to the side of the stem as needed before the stem is hammered to seat the collar properly. A block bone graft is placed between the calcar and collar to reinforce the calcar area as needed. Post-operative therapy allowed full weight-bearing walking from the day after surgery. All activity restrictions were canceled 3 months postoperatively.

Results

The median follow-up period was 4.5 years (range, 3.1–9.5 years). The median operation time was 127 min, the median intraoperative blood loss was 855 mL, and the median length of hospital stay was 8.0 (7–41) days. There were no complications such as intraoperative fractures, symptomatic pulmonary embolism, aseptic loosening, septic loosening, dislocation, or post-operative fractures. The JOA score improved from a median of 63 points preoperatively to a median of 95 points at the final follow-up. The median stem subsidence was 1.4 mm (1–3 mm), with no subsidence exceeding the loosening threshold of 5 mm. There was no circumferential bone radiolucent line around the stem, and spot welds were observed in all cases, indicating remodeling (Table 1). At the latest follow-up, all six stems were retained, with no re-revision or reoperation for any reason.

Case Reports

Case 1

A 48-year-old male underwent bipolar hip prostheses surgery for secondary right hip osteoarthritis following synovectomy for pigmented villonodular synovitis at another hospital. Ten years post-surgery, he experienced pain in the right hip joint during walking. X-rays revealed stem subsidence, central migration of the femoral head, and leg length discrepancy, leading to a diagnosis of aseptic loosening of the stem (Fig. 2a). The bone defect was classified as Paprosky Type II. Femoral prosthesis was revised using IBG with CORAIL, and a cementless cup was placed (Fig. 2b). The operation lasted 168 min with a blood loss of 910 mL. Autologous blood transfusion was used, with transfusion consisting only of recovered blood. Eight and a half years later, X-rays showed stem subsidence of 1 mm (Fig.

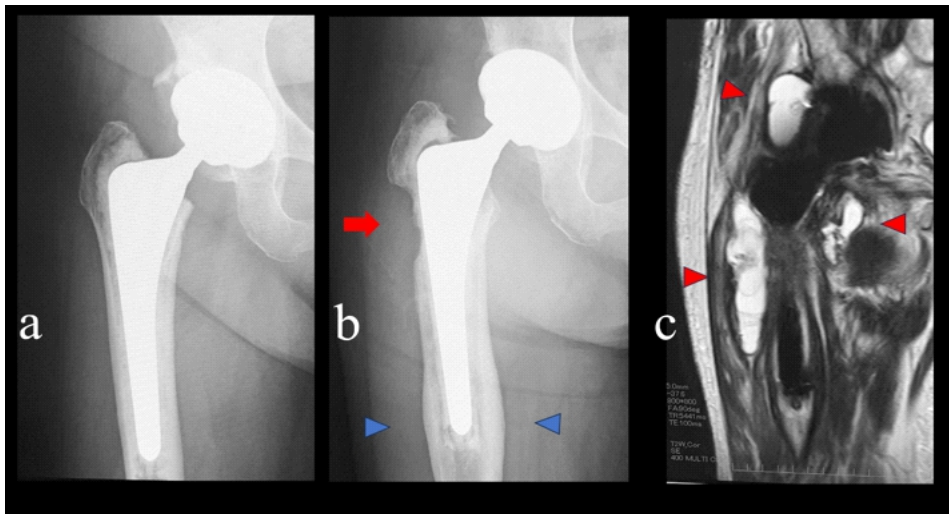

Figure 3: Reason for revision of total hip arthroplasty in Case 2. (a) X-ray after primary cemented total hip arthroplasty. (b) Three years post-operative X-ray showed bone resorption in the proximal lateral femur (red arrow) and cortical hypertrophy at the distal stem (blue arrowheads). (c) Magnetic resonance imaging T2-weighted coronal imaging revealed abscess formation around the prosthesis (red arrowhead).

2c). In addition, comparing computed tomography (CT) images taken 3 months, 2 years, and 5 years post-surgery, remodeling of the bony mass was observed in the calcar region. Remodeling and bone ingrowth were noted in the allograft cancellous bone layer around the stem (Fig. 2d, e, f). The JOA score improved from 62 points preoperatively to 96 points at 8.5 years post-surgery.

Case 2

A 78-year-old female underwent THA at our hospital for right hip osteoarthritis (Fig. 3a). Although the post-operative course was uneventful, X-rays taken 3 years after surgery revealed osteolysis (Fig. 3b). The magnetic resonance imaging of the hip joint showed an abscess around the right hip joint, leading to a diagnosis of pyogenic hip arthritis (Fig. 3c). The bone defect was classified as Paprosky Type IIIa. A cementless cup was replaced on the acetabulum. Strut bone was grafted to the area of the metaphyseal bone defect, and wiring was performed. Femoral prostheses were revised using IBG with CORAIL (Fig. 4a). The operation lasted 167 min with a blood loss of 1400 mL. This case involved an infection, and transfusion of recovered blood was not possible, requiring 4 units of red blood cell transfusion. This case was the only one where the stem subsided more than 2 mm, with a 3 mm subsidence seen on X-ray images a year post-surgery (Fig. 4b). Three years after, remodeling of the strut bone was observed (Fig. 4c). Remodeling of the transplanted bone around the stem was also noted. The JOA score improved from 67 points preoperatively to 97 points at 3 years post-surgery.

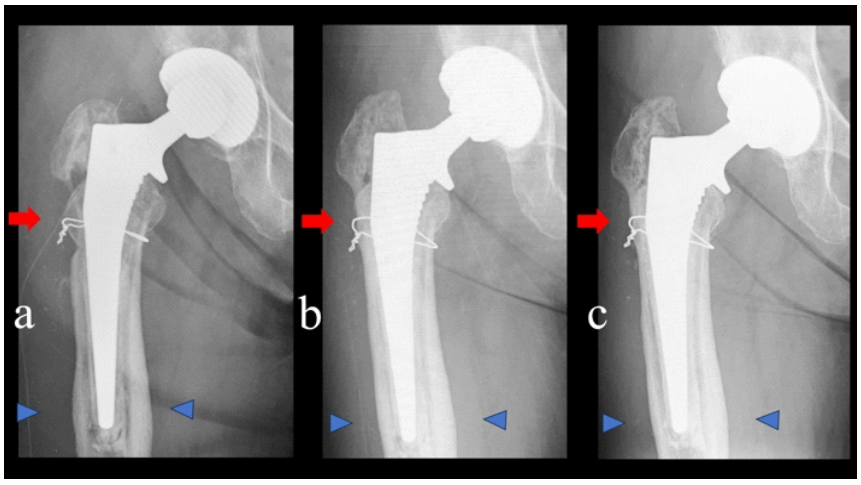

Figure 4: Bone growth and remodeling on X-ray images in Case 2. (a) X-ray after revision total hip arthroplasty. A stem revision surgery was performed using a combination of IBG and a collared fully hydroxyapatite-coated stem. The morselized allograft bone and bulk bone grafting were performed at the lateral defect of the greater trochanter (red arrow). (b) X-ray 1 year postoperatively. The stem had subsided by 3 mm, but the grafted bulk bone showed signs of remodeling (red arrow). (c) X-ray 3 years postoperatively. The allograft bone at the greater trochanter had integrated, making the boundary with the host bone indistinct (red arrow). Cortical hypertrophy at the distal stem had not progressed (blue arrowhead).

Discussion

Good short-term outcomes were demonstrated in these six cases of revision THA using IBG with a collared fully HA-coated stem. The use of IBG with a collared fully HA-coated stem is suggested as a potentially effective means for revision THA of the femoral component.

Revision THA using IBG is often reported with the use of cement systems. Starting from the report by Gie et al. [1] in 1993, good outcomes were reported in 56 cases over 18–49 months. Subsequently, Lamberton et al. [5] performed revision THA using IBG in 540 joints, reporting a loosening-related re-revision rate of 2% at an average follow-up of 6.7 years. Furthermore, Wilson et al. [3] performed revision THA on 705 joints, reporting a loosening-related re-revision rate of 1.2% at an average post-operative follow-up of 14.7 years. Thus, revision THA using the IBG with cement systems has been reported to have good long-term outcomes in many cases. A recent systematic review and meta-analysis of 4102 hips confirmed a 10-year survivorship of 95% for femoral IBG with cemented stems [10], and a Japanese series using the Exeter stem reported a 15-year stem survival of 99% for aseptic loosening [11].

However, there are few reports on revision THA using the IBG with cementless stems. Ishiguro et al. [8] reported a case (our case 1). Nesse et al. [12] randomized Paprosky Grade II 14 patients into two groups intraoperatively, and compared cementless impaction grafting using CORAIL stems with cemented IBG using polished femoral stems. Functional scores and bone density did not differ between the two groups during the 5-year follow-up period. However, radiological data have not been discussed. Masterson et al. [13] reported the long-term results of revision THA using IBG with both cementless and cemented Freeman stems. In the cementless group, stem subsidence of more than 4 mm occurred in half of the cases, intraoperative fractures were observed in 10% of cases, and revision surgery due to loosening was required in another 10%. These results indicate a high incidence of complications. Masterson et al. [13] speculated that the poor outcomes in the cementless group were due to the need for more robust bone grafting and the necessity to restrict weight-bearing until bone fusion was achieved. Nickelsen et al. [14] combined IBG and a cementless, proximally titanium-coated long stem for 100 cases of revision THA, grading bone loss and aseptic loosening according to Engh et al. [15]. Their

Table 1: Patient characteristics and outcomes of revision THA

Variable	6 cases
Age at revision THA, median (range) years	64.3 (47–78)
Sex (Men: Women)	03:03
Reason for revision THA	Aseptic loosening: 5
	PJI: 1
Paprosky classification	I: 1
	II: 4
	IIIa: 1
JOA hip score before revision THA, median (range) points	63 (37–76)
Time from primary to revision THA, median (range) years	9.5 (1.7–20)
Stem type	CORAIL: 3
	UNIVERSIA: 3
Surgical time, median (range) minutes	127 (78–168)
Estimated blood loss, median (range) mL	855 (50–1900)
Length of hospital stay, median (range) days	8.0 (7–41)
JOA hip score at the final follow-up, median (range) points	95 (90–98)
Follow-up period, median (range) years	4.5 (3.1–9.5)
Stem subsidence, median (range) mm	1.4 (1–3)
Bone growth and remodeling	6
Radiolucent line	0
Aseptic loosening	0
Dislocation	0
Fracture	0
Infection	0
Re-revision for any reason	0

THA: Total hip arthroplasty, JOA: Japanese Orthopedic Association, PJI: Periprosthetic joint infection

complication rates showed that 14% of cases had intraoperative fractures, and 17 patients required revision during the average 112-month follow-up period. Nickelsen et al. [14] attributed the poor outcomes in the cementless group to two main factors: First, predominantly early failures associated with early subsidence, indicating a lack of sufficient initial stability, and second, a higher incidence of failures in extra-long stems (250 or 300 mm). A recent systematic review comparing cemented and uncemented stems in femoral IBG found that the uncemented technique was associated with a lower rate of femoral component loosening (1.7% vs. 8.0%), while emphasizing that adequate initial stability is essential to avoid early subsidence [16].

In this study, good post-operative functional scores were obtained in all cases. From the X-ray image, bone fixation was observed in all cases, with a median stem subsidence of only 1.4 mm. There were no cases of intraoperative fractures or cases that led to re-replacement. Collared fully HA-coated stems (CORAIL and UNIVERSIA) used in this study are stems that follow the shape of cement systems and are designed to exert compressive forces circumferentially on the stem. The stem stability and bone ingrowth using IBG with a cement system have been elucidated in previous studies [1,2,3,4,5]. It is believed that similar compressive forces were applied with the CORAIL-type stem, forming a good compressive cancellous bone layer. Furthermore, the use of a collared stem and transplantation of bulk allogenic bone graft into the calcar region contributed to the good fixation by suppressing subsidence. The cementless CORAIL stem has an established long-term track record, with favorable 20-year survivorship reported in primary THA [17]. Although experimental work has shown that early loading influences the incorporation of impacted morselized allograft [18], full weight-bearing from the 1st post-operative day did not compromise graft incorporation or stem stability in the present series.

Most significantly, the CT image of Case 1 provided critical evidence that bone ingrowth occurs between a collared fully HA-coated stem and the compressive allograft cancellous bone layer. The paper presenting this radiographic image is only the case report of Ishiguro [8] and this study, demonstrating the usefulness of using IBG with a collared fully HA-coated stem.

This study had several limitations. First, the sample size was small, and the follow-up period was short due to the decreasing number of revision surgeries as a result of improved outcomes of primary THA in recent years. Second, as cases classified as Paprosky IIIB and C with large bone defects were not included, the outcomes of more complex revision surgeries remain unclear.

Conclusion

IBG combined with a collared fully HA-coated cementless stem may be a useful and effective option for femoral component reconstruction in revision THA, offering both early mechanical stability and biological fixation. Larger series with longer follow-up are warranted to confirm the durability of this technique.

Clinical Message

The combination of the impaction bone grafting technique and a collared fully hydroxyapatite (HA)-coated cementless stem provides an effective biological solution for femoral component revision in total hip arthroplasty. This technique achieves early mechanical stability through the collar and promotes reliable biological fixation via bone ingrowth into the HA-coated surface from the impacted allograft. Clinicians can consider this method as a viable alternative to cemented systems, particularly when biological reconstruction of femoral bone stock is required.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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