

# Bone Preservation in Femoral Intercondylar Box Cut – A Comparative Study between Older and Newer Generation Implants

Haemanath Pandian<sup>1</sup>, Nalli U Sanjeev Kumar<sup>1</sup>, K V Arun Kumar<sup>1</sup>, Nalli R Uvaraj<sup>1</sup>, Mohideen Sheik<sup>1</sup>

## Learning Point of the Article:

The newer generation posterior stabilized implants offer lesser bone volume resected for box cuts compared to the older generation implants, thereby reducing the chance of column fractures.

## Abstract

**Introduction:** This study was conducted to compare the quantity of intercondylar bone removed during femoral box osteotomy for implantation of three contemporary newer generation posterior stabilized (PS) total knee arthroplasty designs Attune PS (DePuy), Anthem (Smith and Nephews), and NexGen Legacy (Zimmer) with the older version from the same manufacturers.

**Materials and Methods:** We compared the maximum volumetric bone resection required for the housing of the PS mechanism of these six designs. Bone removal by each PS box cutting jig was three-dimensionally measured. The differences between the three designs were analyzed by the Kruskal–Wallis test. The Mann–Whitney U-test was used for pairwise comparisons. The level of significance was set at  $P < 0.05$ .

**Results:** The newer generation implants save approximately 33% of bone that was resected from the box cut as compared to the older versions. DePuy's Attune PS saved 27.1% bone as compared to Sigma PS resecting 6.96 cm<sup>3</sup> of bone, and Zimmer's Persona saved 40.57% bone as compared to NexGen from the intercondylar box cut resecting 6.18 cm<sup>3</sup>. Smith and Nephew's Anthem and Genesis have no difference in their box volume with both resecting 7.8 cm<sup>3</sup> of bone.

**Conclusion:** Irrespective of implant size, the Attune PS (DePuy) and Nexgen Legacy (Zimmer) cutting jigs always resected significantly less bone than did the jigs of older generations. There was no significant difference in the bone removed during femoral box osteotomy in the newer and older generations of Smith and Nephew.

**Keywords:** Bone resection, box osteotomy, newer generation prosthesis, cruciate substituting, posterior stabilized, total knee arthroplasty.

## Introduction

Total knee arthroplasty (TKA) is a highly successful operation with high patient satisfaction and good quality of life [1]. The classic posterior stabilized (PS) design makes use of an intercondylar “box” cut on its femoral component for effective kinematics. This box cut houses the post and cam mechanism which prevents anterior sliding of the femur on the tibia in a PS knee where the posterior cruciate ligament (PCL) is resected. Designs of various manufacturers vary in terms of the box but

have tended toward constant box size throughout a range of knee sizes [2,3]. This is a concern for smaller femur sizes where even a small prosthesis has a box cut equivalent to its larger counterpart. This has led to more von Mises stresses experienced by the femur and ultimately leading to intraoperative fractures or iatrogenic fractures [2]. The incidence of intraoperative fracture is around 0.4%–2.2% [2]. Retrospective studies have shown that this complication tends to occur more in the older female population during bone preparation and hammering of components and

## Author's Photo Gallery



Dr. Haemanath Pandian



Dr. Nalli U Sanjeev Kumar



Dr. K V Arun Kumar



Dr. Nalli R Uvaraj



Dr. Mohideen Sheik

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<sup>1</sup>Department of Orthopaedics, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam, Tamil Nadu, India.

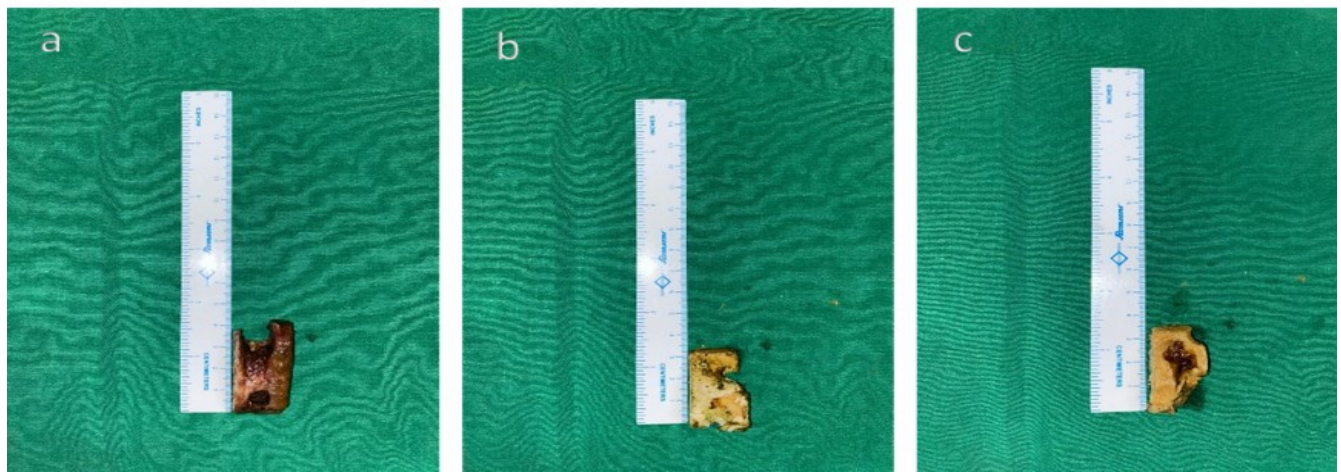
### Address of Correspondence:

Dr. Nalli U Sanjeev Kumar,  
Department of Orthopaedics, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam, Tamil Nadu, India.  
E-mail: nalli95nik@gmail.com

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**Figure 1:** Measurements of box cuts obtained from (a) Attune PS, (b) Genesis PS, (c) Anthem PS implants. PS: Posterior stabilized.

with PS knee.

To overcome this problem, newer generation implants have come up with a new design in their femoral component where box cut ranges according to the size of the prosthesis.

The purpose of the present study was to compare the quantity of intercondylar bone removed during femoral box osteotomy for implantation of the femoral component of three contemporary newer generations PS TKA designs Attune PS (DePuy), Anthem (Smith and Nephews), and NexGen Legacy (Zimmer) with the older version from the same manufacturers.

### Material and Methods

We have compared PS total knee replacement prosthesis of the following: PFC Sigma with the newer system Attune PS of DePuySynthes, NexGen Legacy (newer system) with Persona of Zimmer, and Smith and Nephew’s newer system Anthem with Genesis in terms of the amount of bone resected during

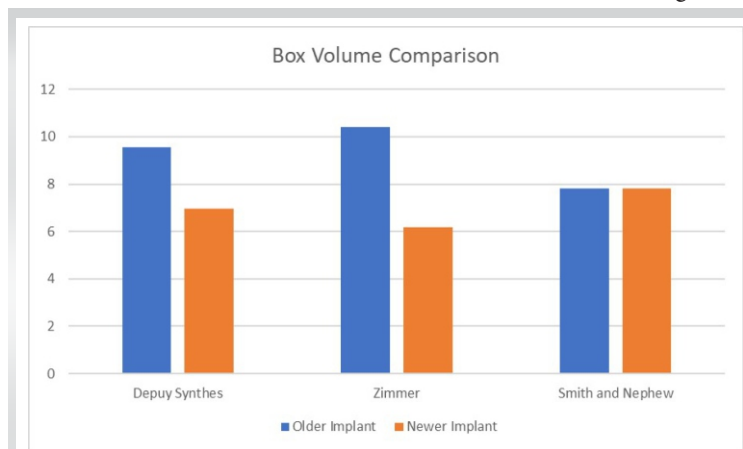
femoral box cut for the smaller sized implants. The height and width vary accordingly and so do the volume of bone resected in each of these systems.

A comparison was made between previous generation implants of the same company with newer generation implants in terms of their box volumes for smaller sizes. We have taken into account the smallest size of each company. DePuy Sigma PFC size 2 has been compared with the 1.5 size of Depuy Attune. Similarly, Zimmer NexGen sizes B and C compared with Persona sizes 1 and 2 and Smith and Nephew Anthem sizes 1N and 2N compared with Genesis 1N and 2N.

Direct measurements of removed bone were acquired for DepuySynthes (Fig. 1a) and Smith and Nephew (Fig. 1b and c), and indirect measurements of removed bone were acquired for the rest by measuring the size of the space for the box osteotomy on each cutting jig. Measurements were acquired 3 times for each sample using a millimeter caliper in an anterior-to-posterior (length), medial-to-lateral (width), and proximal-to distal (depth) direction. Data were collected on an electronic spreadsheet. Statistical analysis was performed using the Kruskal–Wallis test for comparison between groups, with box volume as the dependent variable. The Mann–Whitney U-test was used for pairwise comparisons. Significance was set at  $P < 0.017$  and Bonferroni’s correction was applied.

### Results

On comparing the older generation implants with newer generation implants in terms of volume of bone resected for box cut for smaller sizes, we have come to the conclusion that newer generation implants save approximately 33% of bone that is resected from the box cut.



**Figure 2:** Showing box volume comparison of DePuy, Zimmer, and Smith and Nephew implants.



Sigma PS (box volume cm <sup>3</sup> )	Attune PS (box volume cm <sup>3</sup> )	Difference in box volume resected (cm <sup>3</sup> )	Percentage decrease in box volume resected
9.56	6.96	2.6	27.19%
<b>PS: Posterior stabilized</b>			

**Table 1: Average box volume comparison in Depuy implants.**

DePuy’s Attune PS saves 27.1% of bone as compared to Sigma PS resecting 6.96 cm<sup>3</sup> of bone (Table 1). Similarly, Zimmer’s Persona saves 40.57% of bone as compared to NexGen from the intercondylar box cut resecting 6.18 cm<sup>3</sup> (Table 2). Smith and Nephew’s Anthem and Genesis have no difference in their box volume with both resecting 7.8 cm<sup>3</sup> of bone (Table 3). These results are tabulated in graph form (Fig. 2).

**Discussion**

Preservation or substitution of the PCL in primary TKA is still a controversial issue [4, 5]. Gait analysis, in vivo and in vitro studies showed a reproduction of close-to-normal knee kinematics using either solution [6, 7]. A clinical comparative study between different types of TKA (CR or PS) with identical femoral geometry showed similar mid-term outcomes with regard to a range of motion, functional outcomes, and survival rate [8].

The purpose of this study was to compare the minimum volume of intercondylar bone removable in newly used PS TKA designs. The cam and post mechanism requires an optimum

amount of bone to be resected in PS knee. However, too much resection of intercondylar bone may create a potential stress riser in the distal femur, which may predispose to intercondylar fracture, especially in osteoporotic patients with small femora. In this study, we are trying to simply identify different intercondylar bone-saving instrumentation if a PS solution is needed.

Lombardi et al. concluded that the von Mises stress considerably increases on the medial and lateral condyle after an intercondylar box cut in small-sized femur [8]. It is also of utmost importance that in the smaller-sized femur, the components should be placed centrally since eccentricity may give rise to stress risers in either condyle leading to intraoperative iatrogenic fractures while hammering the prosthesis.

Furthermore, the increase in the constraint level in PS knees rather than CR knees is considered, theoretically, to be an additional stress factor on the bone and the bone-implant interface [9]. These effects will be exaggerated in patients with smaller size femur which is the case in Asians, especially in the

Nex Gen PS (box volume cm <sup>3</sup> )	Persona PS (box volume cm <sup>3</sup> )	Difference in box volume resected (cm <sup>3</sup> )	Percentage decrease in box volume resected
10.4	6.18	4.22	40.57%
<b>PS: Posterior stabilized</b>			

**Table 2: Average box volume comparison in Zimmer implants.**



Genesis PS (box volume cm <sup>3</sup> )	Anthem PS (box volume cm <sup>3</sup> )	Difference in box volume resected	Percentage decrease in box volume resected
7.8	7.8	0	0%

**Table 3: Average box volume comparison in Smith and Nephew implants.**

presence of any additional risk factors such as osteoporosis and obesity.

Small femur sizes, especially ones that would require increased distal resection or change in implant positioning, may benefit from an alternative design without the need for a cam/post mechanism.

In older generations of PS knee, fixed volume of intercondylar bone was resected irrespective of the size. This would create vulnerability of iatrogenic fractures in smaller-sized femur leading to higher chances of complications.

This problem is rectified by companies in newer generation implants by reducing bone resected from the box in a manner that takes away fixed percentage of bone as compared to fixed volume.

This has resulted in the gradual reduction of the volume of an intercondylar box from largest to smallest size.

We have also done a comparison of various implant companies and rectification done in the design and suggested the optimum

amount of bone to be removed from the intercondylar box cut for smoother biomechanics and to prevent iatrogenic fracture [10].

**Conclusion**

Irrespective of implant size, the Attune PS (DePuy) and NexGen Legacy (Zimmer) cutting jigs always resected significantly less bone than did the jigs of older generations. There was no significant difference in the bone removed during femoral box osteotomy in the newer and older generations of Smith and Nephew.

**Clinical Message**

This study does establish that the newer generation PS TKA prosthesis has had suitable modifications to remove less bone at primary TKA. This may be of significance, especially in the Asian race with anthropometric smaller dimension distal femur in preserving as much bone as possible.

**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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**Consent:** The authors confirm that informed consent was obtained from the patient for publication of this case report

#### How to Cite this Article

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