

Assessing Flexibility of Optimized Tibial Cone Sizes in Revision Surgeries, an Anthropometric Analysis

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Disclosures: AM, MS & DH: 3A,4-DePuy Synthes

INTRODUCTION: Success of Revision Total knee arthroplasty (rTKA) is multifactorial. The complexity of rTKA could be further intensified due to osseous defects, caused by infection, implant loosening, wear and osteolysis, bone fractures etc. [1]. Various solutions, such as Cones, Augments, and Sleeves, have been offered to address these defects [1, 2]. Cones are available in several shapes and sizes for establishing metaphyseal fixation when large bone loss is present [1-3]. However, full assessment of the defects and corresponding solutions are typically determined intraoperatively. Moreover, the available shapes and sizes of the Cone may be limited when the surgeon tries to avoid perforation with a host bone. *A priori* knowledge about the flexibility in the Cone sizes could assist the surgeon in making effective intraoperative decisions. Therefore, the objective of this research work was to, using anthropometric approach, determine the level of flexibility that a range of tibial Cone sizes could offer intraoperatively.

METHODS: The Attune® Revision Fixed Bearing (FB) system with Attune® Revision Tibial Cones (DePuy Synthes Inc.) were utilized for this analysis. The FB tibial trays are available in ten sizes. The Cones are offered in three types: Concentric, Bi-Lobe and Tri-Lobe (Fig. 1), with each type available in four sizes: Small, Medium, Large and Extra-Large. Using respective surgical techniques for the Intramedullary approach, virtual implantation was performed in 1864 tibial bone models using MatLab workflow. The tibial resection level was maintained at 12mm from the unaffected plateau, with a posterior slope as that of the tibial tray. A previously developed algorithm was used to determine the tray size and its orientation that will maximize tibial coverage [4]. The Press-Fit stem was introduced on the distal end of the tray. Later, Small size Cone of each type was implanted coinciding with the resection plane and along the tray-stem axis. The process was repeated with next size Cone, until the Cone periphery was within 3mm of the corresponding tibial bone surface (Fig. 1). This peripheral clearance was used as an indication of minimal risk of perforation. To assess the flexibility in sizing for a given Cone type, the Cone sizes with acceptable peripheral clearance were recorded. The process was repeated in all 1864 tibiae, and the percentage of tibiae with corresponding sizing flexibility for each Cone type was reported. Furthermore, Cone sizing distribution against tibial tray size was recorded.

RESULTS: For each Cone type, the percentage of tibia accommodating different Cone sizes without bony perforation are summarized in Fig. 2-a. 100% of tibiae used at least one Cone without any bony perforation. For Concentric Cones, 100% of Tibiae used at least one size Cone, out of which 60% tibia could utilize two or more sizes to fill the bony defects, whereas 10% of tibiae could utilize all available sizes. 94% of tibia used at least one size of the Bi-Lobe Cones. Out of which 57% tibia used Small size Cones, whereas 43% tibiae utilized two or more Cone sizes to fill the defects. For Tri-Lobe Cones, 81% of tibiae used at least one size Cone. Out of those, 66% defects were addressed using Small size, whereas defects in 34% cases were filled by the rest of the three sizes. The Cone size and tray size distributions for all three Cones is summarized in Fig. 2-b,c,d. For all three types of Cones, the mid-size trays (Size 4-7) used more of the Small and Medium size Cones, whereas, larger tray sizes (Size > 8) utilized all four sizes.

DISCUSSION: Tibial bone loss and its severity is difficult to anticipate preoperatively. Complete assessment and examination of the defect typically occurs after removal of the affected tibial implants. Preoperative understanding of how certain types of Cones, and which sizes of those Cones can address defects, could assist surgeons intraoperatively. The results observed in this study highlighted that the type and size ranges of studied Cones would address defects in 100% studied tibiae without any risk of bony perforation. All Cones included in this study uses AFFIXIUM™ 3DP Technology, which is a porous Titanium structure. The bony perforation could influence the osteointegration process and consequently affect the construct stability. Therefore, in this analysis, peripheral clearance between Cone and tibial bony surface was utilized to determine acceptable Cone size. The analysis also revealed the relationship between Cone and tray sizes. Larger size trays were used in larger bones; therefore, the sizing distribution emphasized that the (patients with) mid-size tibia would more often utilize Small size Cones. Contrary, surgeons would have more choices in Cone selections for the (patients with) larger tibia. In summary, the work demonstrated that at least one size of the studied Cones would address the tibial defects in 100% studied cases, and in 30%-60% of cases (depending on Cone type), Surgeons would be able to select Cones from more than one sizes without causing bony perforations.

SIGNIFICANCE/CLINICAL RELEVANCE: The anthropometric analysis demonstrated the methodology to qualify acceptable Cone sizes which would minimize bony perforations.

REFERENCES: 1. Lei *et al.*-2019, 2. Bolam *et al.*, 2022, 3. Bassini *et al.*, 2017, 4. Clary *et al.*, 2014

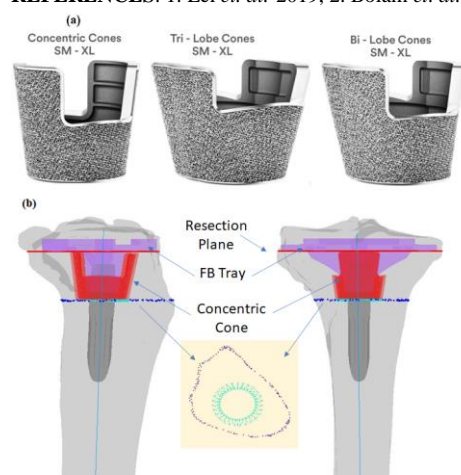


Figure 1. (a) Attune® Revision Tibial Concentric, Bi-Lobe and Tri-Lobe Cones. **(b)** Attune® FB tibial tray with Concentric Cone virtually implanted in a Tibial bone. Tibial tray size was determined by maximizing the proximal tibial coverage, while resection plane and Canal axis is used to place the tray, Stem and Cone. Clearance between tibial bone surface and Cone was used to assess bony perforations.

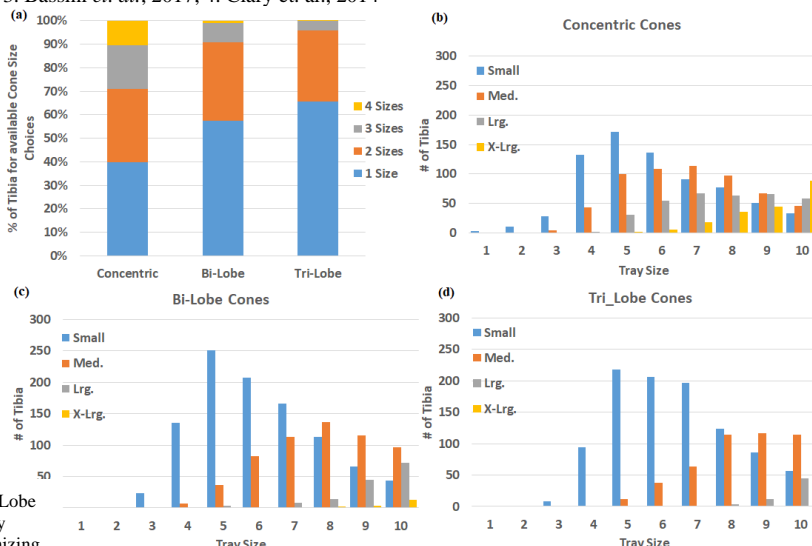


Figure 2. (a) Percentage of Tibia utilized different Cone sizes without bony perforations for the Concentric, Bi-Lobe and Tri-Lobe Cones. **(b-d)** The Cones and tibial tray sizes distribution for the Concentric, Bi-Lobe and Tri-Lobe Cones