The Shape of the Resected Patella and Design Factors Affecting Bone Coverage and Restoration of Patella Anatomy

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Introduction: Surgeons must consider many factors while setting the appropriate cut depth and component orientation during resurfacing of the patella in total knee replacement (TKR). Restoration of the natural patella thickness after resurfacing aids in preventing over-stuffing of the patella-femoral joint, while maintaining a minimum thickness of the remaining bone prevents patella bone fracture [1]. When placing the patella component, surgeons strive to maximize coverage of the cut patella-bone while restoring the medialization of the peak of the native articular geometry to obtain more natural patella-femoral kinematics [2]. The design of the patella components aids surgeons in their surgical decision making. The purpose of the current study was to compare the design attributes of various patella resurfacing implants and assess their influence on maximizing coverage, restoring the pre-operative patella thickness, and matching the medialization of the native articular geometry.

Methods: Ninety patella bones were segmented from pre-operative computed tomography scans of total knee replacement patients. A cut plane for the patella resurfacing was established mutually parallel to lines connecting the medial and lateral poles in the coronal plane, and connecting the superior and inferior points on the articular ridge in the sagittal plane. The resection level of the cut was set to the thickness of the patella resurfacing component so as to restore the pre-operative thickness of the patella. In situations where the minimum thickness of the bony remnant dropped below 12 mm, the resection depth was reduced to maintain this thickness [2]. Patella component position and orientation on the bone was set using two philosophies. In the first instance, the implant size, medial-lateral (M-L) and superior-inferior (S-I) implant positions, and rotational orientation were mathematically optimized to maximize patella coverage without regard for restoring the natural medialization of the articular ridge. In the second instance, the peak of the implant was aligned to the peak of the pre-operative articular ridge along the M-L axis, while the implant size, S-I position, and rotational orientation of the component was optimized to maximize bone coverage. In both alignment scenarios, less than 2-mm of the implant overhanging the bone’s periphery were allowed. Once the component was placed, the overall coverage and the restoration of the natural medialization were assessed, in addition to the radial distance from the periphery of the component to the periphery of the bone. The patella resurfacing was performed with four different styles of patella implant. Implant 1 (Attune Medialized Dome Patella, DePuySynthes, Warsaw, IN) had five sizes, an oval periphery, but with a centralized articular peak. Implant 2 (Attune Medialized Anatomic Patella, DePuySynthes, Warsaw, IN) also had 5 sizes, had a more rectangular periphery, and medialization of the articular peak. Implant 3 (Sigma Oval Dome, DepuySynthes, Warsaw, IN) had four sizes, an oval periphery, but with a centralized articular peak. Implant 4 (NexGen, Zimmer, Warsaw, IN) had 5 sizes, a round periphery, and a centralized articular peak.

Results: When placed to maximize coverage, all styles of patella resulted in similar levels of coverage, with Implant 2 (Attune Medialized Anatomic) demonstrating the best overall coverage (80% ± 8%). In addition, when maximizing coverage, Implant 1(Attune Medialized Dome) most accurately restored the peak of the native articulation to within 0.0±1.2-mm (Fig. 2). The components with a centralized articular peak caused a ~2.5-mm lateral shift of articulation relative to the native articular ridge. When the implant was placed to restore the native peak of the articular geometry, the Attune Medialized Anatomic Patella again had the best overall coverage of the patella cut surface at 78% ± 9% (Fig. 1). The components with a centralized articular peak (Implants 3-4) placed to restore the native medialized ridge resulted in a smaller patella component 43% and 49% of the time, respectively, compared to when maximizing the coverage. In addition, these components were medialized on the bone leaving an average of 5-mm of overhanging bone laterally. Implants incorporating a medialization of the articular surface (Implants 1-2) maintained coverage while restoring the medialized ridge of the native articular geometry (Fig. 2). Bone resection depths were rarely modified to ensure a sufficient bony remnant (10%, 11%, 11%, 12% of the time, respectively), primarily occurring in smaller patella.

Discussion: Several design factors were identified which influenced the ability for the patella implants to both maximize coverage and restore the native medialization. When maximizing coverage, all patella shapes resulted in similar levels of coverage. Implant 3 had one fewer size than the other systems which likely led to the slight reduction in coverage. However, if the patella had a centralized articular peak, maximizing coverage led to a lateral shift of the articular peak by 2.5-mm which may adversely affect patella-femoral kinematics [2]. In contrast, designs with medialization of the articular surface (Implants 1-2) more accurately restored the natural medialization without significantly reducing patella coverage. When restoring the native articular peak, components with a centralized articulation left exposed bone laterally that may articulate with the femur and contribute to anterior knee pain. Caution should be used when placing the patella implant to balance bone coverage and
restoring the native articulation and should be influenced by the design of the patella component.

**Significance:** This study compares the performance of various patella resurfacing implants on maximizing bone coverage and restoration of the native articular geometry in aid surgeons in implant placement during total knee replacement.

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Figure 1: Overall percent bone coverage for each implant system subjected to both surgical practices (maximize coverage, restore peak)
Figure 2: Resurfaced patellae with average underhang (mm) for two surgical techniques and four implant systems. Natural medialization of the articular cartilage (red) and the implant peak (black) are shown on the patella.