



Gender optimized patellar component designs are needed to better match female patellar anatomy

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ABSTRACT

Background: Avoidance of both over-resection of the native patella, and over-stuffing of the patello-femoral joint are advocated to reduce the risk of patellar complications following patellar resurfacing. Female gender, due to thinner native patella, and use of patellar prostheses from one specific manufacturer that were thicker for comparable diameters than the patellar prostheses from a second manufacturer were hypothesized to be risk factors for these undesirable technical outcomes.

Methods: A retrospective review was undertaken of 803 consecutive knee replacements, performed by one surgeon, during which the same patellar resurfacing technique had been used, but with two different patellar implant designs.

Results: Female gender, and use of one specific design of patella prostheses were associated with both increased risk of patellar over resection to ≤ 13 mm residual patellar thickness, and creation of a patella construct that was thicker than the native patella ($p < 0.001$).

Conclusions: Patellar prostheses design can contribute to compromises in surgical technique during patellar resurfacing in TKA in female patients with thinner patellae. Modifications to current patellar prosthesis dimensions may be considered to allow surgeons to more accurately resurface the thinner, native female patella.

Level of Evidence: III

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1. Introduction

Patellar resurfacing in total knee arthroplasty (TKA) is controversial with significant regional and international practice variations [1–3]. Potential advantages of patellar resurfacing have been reported, including lower revision rates [4–7]. However, unique complications including greater risk of post-operative patellar fracture, patellar mal-alignment, and patellar component failure are also attributed to resurfacing [2]. Many of these problems have been attributed to poor surgical technique [2]. Therefore, if resurfacing is undertaken, close adherence to generally accepted surgical principles is recommended [1,2,8–11]. Particular concerns after resurfacing of the patella include both over-resection of the native bone to less than 12–15 mm that may contribute to increased risk of fracture; and conversely over-stuffing of the patello-femoral joint, which has been implicated in reducing post-operative flexion [2, 9–14]. In some cases, where the native patellar bone is thin, or when the components are thick, the surgeon may need to compromise one or both of these principles by choosing to resect more patellar bone, in

order to avoid over-stuffing, or accept an increase in the composite thickness of the resurfaced patella.

This research was conducted in two parts: In the first part, we investigated whether patient gender and prosthesis design are factors that may lead to over resection of the patella, or an increase in composite patellar thickness. We specifically examined three issues: 1) are there gender differences in the thickness of the native patella and differences in the maximal diameter of patellar component that could be accommodated on the prepared patellar surface without overhang? Our hypothesis was that women have thinner patellae and would therefore only be able to accommodate smaller diameter patellar components; 2) do differences in the native patellar thicknesses between male and female knees result in a greater risk in female knees of resection of the patella to less than 13 mm, or an increase in the composite thickness after resurfacing? Our hypothesis was that female knees would be at greater risk of both of these undesirable outcomes due to the thinner native patellae; 3) does the thicker patella prosthesis (for any given diameter) made by one manufacturer result in a greater risk of resection of the patella to less than 13 mm, or an increase in the composite patella thickness after resurfacing? Our hypothesis was that thicker components from one manufacturer would be a risk factor for both of these undesirable outcomes.

The second part of the study was performed to determine the theoretically optimal diameters and thicknesses of patellar components for male and female knees. Once these dimensions were defined, we

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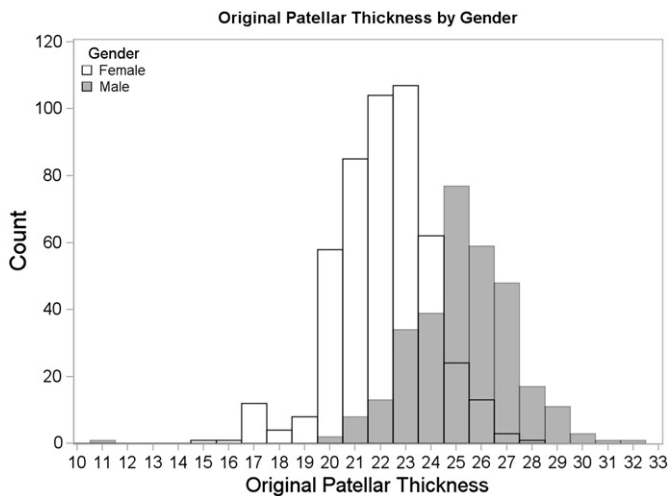


Fig. 1. Distribution of original patellar thickness by gender.

compared these optimal components to the available patellar prostheses in contemporary knee systems in the United States. Our hypothesis was that improvements in patellar component dimensions should be considered in order to allow accurate patellar resurfacing to be performed, especially in female knees.

2. Materials and methods

Institutional review board approval was granted for a retrospective review of patient records and imaging studies. Eight hundred three knees that had undergone TKA with a single surgeon at our institution between 2006 and 2010 were reviewed. Seven hundred ninety-three knees (480 female knees, 313 male knees) underwent patellar resurfacing; four knees had patellae that were too thin to consider resurfacing (less than 10 mm of remaining bone), and six knees had undergone prior patellectomy. In all cases where the patella was resurfaced areas of grade III or IV articular cartilage damage were identified but the area of damage was not documented. Patellar resurfacing was undertaken with a round, all polyethylene patella; 522 were made by company A (Zimmer, Warsaw, IN), and 265 were made by company B (Stryker, Mahwah, NJ).

The surgical technique was identical in all patients. Regardless of the manufacturer of the final patellar implant, the same reaming system was used to prepare the native patella to a specific thickness of residual

bone. This thickness was based upon an estimate of the likely diameter and thickness of the component that would be accommodated. The specific surgical steps were: 1) Measurement to the nearest millimeter of the maximal antero-posterior thickness of the native patellar thickness after removal of peripheral osteophyte using a hand held mechanical caliper that was calibrated in one millimeter increments (similar technique and validated caliper have been described in prior reports) [9, 12,13,15–17]; 2) reaming of the native patella to the specified desired thickness; 3) selection of the largest round patellar component that can be accommodated on the prepared patellar surface, without creating overhang; 4) removal of any un-resurfaced lateral facet with an oblique osteotomy using a saw; 5) measurement of the composite thickness after resurfacing using the hand held caliper; and 6) further freehand resection of the residual patella if the composite thickness was judged too thick (generally >1 mm increase in composite thickness).

Data gathered from the medical records included patient gender, native patellar thickness, diameter and thickness of the component used, and composite thickness of the resurfaced patella.

2.1. Statistical analysis

The thickness of the residual patella was calculated by subtracting the known thickness of the component used from the composite thickness of the resurfaced patella. All statistical analysis was performed using SAS version 9 (SAS Institute, Cary, North Carolina). The percentages of positive thickness changes between groups were compared by the Chi-square test, and the odds ratio of positive thickness change was reported. Similar analysis was performed for comparing the percentages of residual patella between groups. The mean and standard deviation for implant size and pre-patella thickness were calculated, and the mean values between male and female patients were compared by the two-sample t-test. A p value of <0.05 was selected for determining statistical significance.

3. Results

The mean native patellar thickness was 22.1 mm (SD 1.89) in female knees versus 25.2 mm (SD 2.11) in male knees; this difference was statistically significant ($p < 0.001$) with female patients having thinner patellae on average (Fig. 1).

The mean diameter of the largest patellar prosthesis that could be accommodated on the prepared patellar surface was 31.4 mm (SD 2.20) in female knees versus 35.2 mm (SD 2.42) in male knees; this difference was statistically significant ($p < 0.001$) with female patients accommodating smaller diameter prostheses (Fig. 2).

Female gender is a risk factor for a post-resection residual patellar thickness of ≤ 13 mm. One hundred twenty-three of 480 (26%) female knees had a post-resection residual patellar thickness of ≤ 13 mm versus 12 of 313 (4%) male knees ($p < 0.001$). Female knees were eight times more likely than male knees to have a post-resection residual patellar thickness of ≤ 13 mm.

Female gender is a risk factor for increasing patellar thickness: 120 of 480 female knees (25%) had an increase in composite thickness after resurfacing versus 47 of 313 (15%) male knees ($p < 0.001$). Female knees were 89% more likely to have an increase in final patellar composite thickness than male knees.

Patellar prosthesis manufacturer was also a risk factor for increasing composite patellar thickness. Eighty-eight of 522 knees (17%) with a patellar prosthesis from manufacturer "A" had an increase in final patellar composite thickness versus 79 of 265 (30%) from manufacturer "B" ($p < 0.001$). Knees that received an implant made by manufacturer B were twice as likely to have an increase in their final composite thickness.

Comparing native patellar thickness to the maximum diameter of the patellar component that could be accommodated in both female and male knees about 1/3 of female knees have a native thickness of between 17 and 21 mm, and about 75% can accommodate a component of between 26 and 32 mm in diameter (Tables 1 & 2). In distinction, about 85% of male knees have a native patellar thickness between 23 and 28 mm, and the majority (65%) accommodate a patellar component 35 mm or larger in diameter (Tables 1 & 2). The diameter of the native patella versus the diameter of patellar component that was used is displayed in Fig. 3.

4. Discussion

Patellar resurfacing in TKA is controversial with advocates for and against routine re-surfacing [3,4,6,8]. When the surgeon chooses to

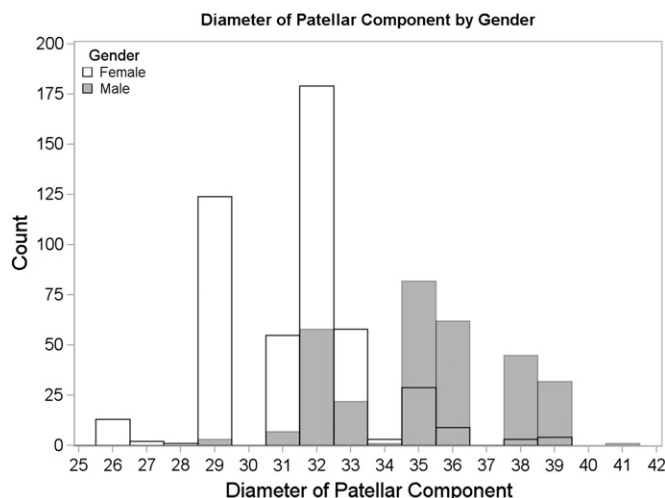


Fig. 2. Diameter of patellar component used by gender.

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