THE EFFECT OF PATELLA PEG ORIENTATION ON BONE/CEMENT/IMPLANT INTERFACE STRENGTH

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Introduction

Most all polyethylene patellae used in Total Knee Arthroplasty employ pegs and cement grooves for fixation, but the typical surgical technique does not specify any particular orientation of the patellar pegs. The peg orientation may critically affect the strength of the bone/cement interface bond. As the patella tracks along the trochlear groove, the quadriceps force tends to pull the patella laterally, as well as superiorly. This lateral force is partially resisted by the patella’s position in the trochlear groove, which prevents subluxation. The combined forces create a shear force across the patella bone/implant interface. The goal of this study was to test this bone/implant cement interface bond with several different orientations of the patellar component, and to determine the optimal orientation for three pegged polyethylene patellar components.

Methods

A shear force was applied to each patella, as would occur in vivo. The patellae were cemented onto artificial bone substitute per surgical technique and were then subjected to shear forces, representative of superior-lateral muscle forces.

Eighteen, Size 3, 7mm thick, Natural-Knee All-Polyethylene Patella (Sulzer Orthopedics, Austin, TX) were employed for this bone/implant interface investigation. The patellae were implanted onto eighteen blocks cut from bone substitute (Last-A-Foam with a density of 0.288g/cm, Model Number FR 3718 (General Plastics Manufacturing Company, Tacoma, WA 98409)) in different orientations.

The patella peg orientation with one peg medial and two lateral was considered group 1. The patella peg orientation with two pegs medial and one lateral was considered group 2. The third patella peg orientation with one peg medial, one distal, and one lateral was considered group 3.

Medial

Lateral

Group 1 Group 2 Group 3

Figure 1: Three Peg Orientations (top of picture - medial, bottom - lateral)
The patella specimens were tested for shear strength characteristics with an Instron (Instron Corporation, Canton, MA 02021) at room temperature. The bone substitute was cut into approximately 3” x 3” x 3” (76mm x 76mm x 76mm) blocks. The surgical patella drill guide was placed in the center of the block and fixed in place per the recommended surgical technique (via three drill pins). Care was taken in noting the orientation of the peg holes (Figure 1). The blocks were marked for their peg orientation. Instead of true bone cement, another polymethylmethacrylate (PMMA, Acra Fast Light Veined Cold Cure Resin (Neoloy/Dentex Inc., Long Island City, NY 11101) and Acra Fast Monomer (Austenal, Chicago, IL 60632)) was mixed per manufacturer’s directions. After mixing, the PMMA cement was allowed to sit until a doughy consistency was achieved, also per the recommended surgical technique. The cement was spread over the anterior surface of the patella while taking care to completely cover the pegs and the cement groove. The patella was firmly pressed into the pre-drilled blocks of bone substitute material. The patella was clamped onto the bone substitute per recommended surgical technique and allowed to fully cure overnight.

The bone substitute with the cemented patella was affixed to the lower platen of the Instron and a shear plate was attached to the upper platen, such that the Instron could apply a laterally directed force. The plate was lowered to just above the patella. The shear plate was centered over the patella and oriented parallel to the bone substitute. The shear force was applied by lowering the crosshead at a speed of 2 in/min (50.8 mm/min). The peak load required to separate each patella from bone substitute was recorded.

![Test Set-up to Apply a Laterally-directed Patella Shear Load](image)

**Figure 2**: Test Set-up to Apply a Laterally-directed Patella Shear Load
Results and Discussion

The patella peg orientation with one peg medial and two lateral (group 1) required an average shear load \( \pm s_{n-1} \) of 282±11lb (1250±49N) to separate the patella from the bone substitute. The patella peg orientation with two pegs medial and one lateral (group 2) required an average shear load \( \pm s_{n-1} \) of 339±17lb (1508±76N) to separate the patella from the bone substitute. The third patella peg orientation with one peg medial, one posterior, and one lateral (group 3) required an average shear load \( \pm s_{n-1} \) of 329±28lb (1463±125N) to separate the patella from the bone substitute. A student’s t-test found a statistically significant difference (with a confidence level of 95%, \( p<0.05 \)) between group 1 and the other two groups. Groups 2 and 3 were found to be statistically equivalent (\( p>0.05 \)).

When implanting cemented all-polyethylene patellar components, which employ three pegs to contribute to a bone/cement interface bond, specific attention to the peg orientation is beneficial. The peg orientation with one peg medial and two lateral proved to be the worst scenario for patella resurfacing in laboratory testing.