TIBIAL COMPONENT FIXATION WITH CEMENT: THE EFFECT OF STEM TYPE AND SURFACE CEMENTATION VERSUS FULL CEMENTATION OF THE TIBIAL COMPONENT

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Introduction:
Although long-term results in cemented TKA have generally been excellent, controversy exists regarding the optimal cement fixation method and stem design for the tibial component in TKA. Loosening of the tibial component continues to be the primary mode of failure in both cemented and non-cemented TKA. A principal factor in accomplishing long-term success of TKA is the initial fixation of the tibial component. This study compares initial tibial component fixation in two cementing techniques and two stem designs. Proponents of full cementation (FC) argue that better short and long-term fixation of the tibial component is achieved and that these advantages outweigh the possible slight increase in tibial bone loss that would arise should revision ever become necessary. Proponents of surface cementation (SC) and press-fitting of the tibial stem in the metaphysis argue that sufficient implant stability is achieved without the potential for metaphyseal bone loss should revision become necessary. The goals of this study were to compare the initial tibial component stability, when the cemented tibial tray was implanted using one of two cementation techniques (FC or SC) in two stem geometries (cruciate and I-beam), and with either cruciate or I-beam stems using the SC technique. The hypotheses tested were 1) the FC technique would reduce micromotion of the tibial tray relative to the bone surface, and 2) the cruciate and I-beam stem geometries would have similar initial stability.

Methods:
Twelve matched pairs of fresh-frozen cadaveric tibiae (mean age of 41 ±13 years) were divided into three groups of four for this study: 1) FC vs. SC in cruciate stems, 2) FC vs. SC in I-beam stems, and 3) cruciate vs. I-beam stem implanted with SC.

Specimen preparation:
Each proximal tibia was resected using the manufacturer’s standard surgical technique following the manufacturer’s specifications. The metaphysis was broached for either an I-beam or cruciate stem. The cut surface was pulse-lavaged and dried with compressed air. The tibial component was a grit-blasted titanium implant (Maxim Complete Knee System, Biomet, Warsaw, IN, USA) with a modular connection for the stem. Two primary 40 mm stem geometries, I-beam and cruciate were used. For FC vs. SC comparisons, one tibia in each pair received FC while the contralateral tibia received SC. For cruciate stems vs. I-beam stems placed with SC, one tibia in each pair received the cruciate while the contra lateral tibia received the I-beam. Tibiae receiving SC technique had bone cement pressurized into the tibial plateau and spread on the tray’s undersurface. Tibiae receiving the FC technique, additionally, received unrestricted cement placed into the stem canal and spread onto the stem.

Experimental apparatus:
A halo and transducer method for component-bone micromotion measurement was used [1]. Micromotion was measured using differential variable reluctance transducers at four sites: medially, laterally, anteriorly, and posteriorly. Specimens received an eccentric cyclic load (50-1500 N) applied to the midpoint of the polyethylene insert on the medial tibial plateau for 6000 cycles at 1 Hz using a servohydraulic Instron materials testing machine. This loading model was used to simulate the load that might arise as 60% of three times body weight passed through the medial tibial plateau of an 85 Kg (850 N) man in the stance phase of gait. Post-implant AP and lateral radiographs of all twelve pairs of tibiae were used to measure variation in the depth of cement penetration and were included in a comparison of the depth of cement penetration achievable with each cementing technique.

Statistics:
Comparisons were made between each group using a Paired t-Test. Significance was determined at alpha ≤ 0.05.

Results:

Micromotion Comparisons:
Micromotion of the tibial trays was analyzed in all four positions and total (the sum of the motion at each position) over six thousand cycles. No significant differences were measurable for any positions or total micromotion between the two cementing techniques in matched paired tibiae implanted with cruciate stems.

<table>
<thead>
<tr>
<th></th>
<th>Medial</th>
<th>Lateral</th>
<th>Anterior</th>
<th>Posterior</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cruciate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FC</td>
<td>12.08</td>
<td>2.82</td>
<td>8.72</td>
<td>5.48</td>
<td>29.10</td>
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<tr>
<td>SC</td>
<td>16.45</td>
<td>3.57</td>
<td>4.16</td>
<td>6.70</td>
<td>30.67</td>
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</tbody>
</table>

In matched paired tibiae with I-beam stems, the SC demonstrated significantly less micromotion at the medial position (p=0.042) and in total micromotion (p=0.035).

<table>
<thead>
<tr>
<th></th>
<th>Medial</th>
<th>Lateral</th>
<th>Anterior</th>
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<th>Total</th>
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<tbody>
<tr>
<td>FC</td>
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<td>3.23</td>
<td>11.22</td>
<td>7.71</td>
<td>50.13</td>
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<td>2.79</td>
<td>11.36</td>
<td>5.61</td>
<td>27.79</td>
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</tbody>
</table>

No significant differences were detected between Cruciate and I-beam stem geometries in matched paired tibiae fixed with SC.

Cement Penetration:
The average depth of cement mantle penetration for all specimens was between 3.6 mm (min) and 4.9 (max). No significant differences were detected between the various cementation techniques and stem geometries.

Discussion:
The major mode of failure in cemented TKA, as well as cementless TKA, remains loosening of the tibial component. Initial implant stability of the tibial component plays an important role in the realization of long-term TKA survivorship. The purpose of this study was twofold: to compare the biomechanical stability of initial fixation of fully cemented versus surface cemented tibial trays with two different stem geometries in cadaver tibiae, and to directly compare two commonly utilized stem designs (cruciate – I-beam) in primary TKA. Our data indicates that the initial stability achievable in both Cruciate and I-beam stems with SC is comparable to that achievable with FC under an eccentric load applied to the medial side. No differences in initial stability were found between the cruciate and I-beam stems. Additionally, no differences were measured in the depth of cement penetration between the two cementing techniques and stem geometries. These findings point to the need for further study comparing FC to SC. Different loading conditions such as torsion, and shear need to be addressed. Implantation of the tibial tray using SC may become the cement technique of choice in TKA, if after further biomechanical testing, these two cementing techniques are found to be equivocal.


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