Tamp-Stem Mismatch Determines Cement Mantle Thickness, Cement Penetration Depth and Subsidence of Impaction-Grafted Femoral Stems

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Introduction: Impaction bone grafting is used to reconstitute bone loss at revision total hip replacement (THR). The technique involves impaction of morselized cancellous bone with special instruments. Most often, the femoral stem is cemented following impaction grafting. For primary total hip replacements a cement mantle thickness between 2 mm and 5 mm has been recommended. The adequacy of the cement mantle around various designs of impaction-grafted stems has been compared and deemed inadequate around the Exeter system [1]. Yet, good clinical results have been reported with the Exeter impaction system [2].

The conventional wisdom of solid cement mantles has been questioned by the low migration and high survival rates of stems inserted with a very thin cement mantle – the so called “French paradox” [3]. One explanation for the good performance of such stems is the stronger interlock between bone and cement due to the higher cement pressures generated around a canal-filling stem [3].

We performed this study to investigate the contradiction between inadequate cement mantle and good clinical results of impaction-grafted stems. Specifically, we addressed two questions: (1) Does cement mantle thickness affect cement penetration depth? and (2) Does cement mantle thickness affect early mechanical stability?

Materials and Methods: Twelve large composite femora (#3103-2; Sawbones, Malmö, Sweden) were prepared to simulate cavitary defects by removing all foam representing cancellous bone and reaming the medullary canal to an internal diameter of 18 mm. Freshly frozen porcine cancellous bone was morselized using a bone mill (Noviomagus; SMT, Nijmegen, The Netherlands).

The cavitary defect was reconstructed by impaction grafting using the X-Change system (Stryker, Newbury, UK), using a size 0, 1 or 2 final tamp. Bone cement (Palacos-R, Zimmer, Swindon, UK) was then injected, and a size 0, 1 or 2 femoral stem (Exeter, Stryker, Newbury, UK) inserted. A corresponding tamp/stem combination leaves a solid cement mantle of 2 mm. By independently varying size of the tamp will leave a smaller gap for cement to escape during stem insertion, thus increasing cement penetration. Stem motion can occur at the stem/cement interface, at the cement/graft interface, through graft deformation, or at the graft/bone interface. That a thinner solid mantle decreases any of these motion components is hard to explain. However, deeper cement penetration into the graft will improve the interlock between cement mantle and graft, decreasing motion at the cement/graft interface. The penetrated cement will also increase the strength of the impacted graft by reducing rolling and sliding of the particles. Increased cement penetration due to a thinner solid mantle is therefore the most likely explanation of reduced subsidence.

In conclusion, a thinner cement mantle will be associated with deeper cement penetration and reduced stem subsidence upon loading. This association may explain the good long-term results of impaction-grafted Exeter stems, despite deficient solid cement mantles.


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