

Optimizing Core Decompression through 3D Simulation and Personalized Instrument Selection.

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INTRODUCTION:

Core decompression is a leading treatment of osteonecrosis of the femoral head (ONFH) to prevent collapse. Studies have demonstrated that success depends on the volume of osteonecrotic bone resected, but excess removal of healthy bone, particularly cortical bone, increases the risk of fractures. Expandable reamers optimize the resection of necrotic bone while preserving healthy bone by being introduced through a small shaft and expanding within the femoral head to resect necrotic bone. With various expandable reamers available, we aimed to evaluate how different instruments perform in ONFH lesions. We developed a composite score $Z = \text{Volume_ONFH} / (\text{Volume_ONFH} + \text{Volume_Healthy})$ to compare the volume of necrotic and healthy bone removed by each instrument. This score ranges from 0, with no necrotic bone removed, and a theoretically perfect score of 1 with only necrotic tissue removed.

METHODS:

We conducted a retrospective study on patients who underwent core decompression for ONFH. Using 3D models of patient's femurs and ONFH lesions (created from perioperative CT imaging), five instruments were simulated; single 2.8mm pin, multiple pins, single 5.0mm drill, and two expandable reamers: a 3.5mm shaft with 12mm expansion, and a 5.0mm shaft with 18mm expansion. We measured the volumes of healthy and necrotic bone removed and calculated the composite scores. Continuous variables were compared using Wilcoxon signed rank test. A generalized additive model was used to evaluate the relationship between score and lesion size.

RESULTS:

Both expandable reamers significantly outperformed pins and cannulated drill bits. The largest expandable reamer removed the most necrotic bone, at the cost of removing healthy bone. The smaller expandable reamer removed less necrotic bone than the larger reamer but also resected less healthy bone. For ARCO 2021 type 2/3 lesions, the larger reamer had a superior score, but for ARCO type 1 and small volume lesions, the smaller reamer was not significantly different.

DISCUSSION AND CONCLUSION:

Expandable reamers remove more necrotic bone while preserving healthy bone better than drills or pins. The 18mm reamer is generally superior, except for small lesions or early-stage lesions, in which the 12mm reamer may be equivalent. Further work is needed to evaluate the differences in these instruments' performance in clinical practice.

