Accuracy of robotic assisted femoral osteochondroplasty for treatment of FAI

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Introduction: There is strong evidence that mechanical and structural changes around the hip are major etiological factors in the development of osteoarthritis, currently 90% or more of hip osteoarthritis cases can be attributed to anatomical abnormalities [1, 2]. These structural deformities can be corrected with a range of operative strategies (eg osteotomies) to improve patient symptoms and delay osteoarthritis progression[3].

One of the most important and provocative new hypotheses in orthopedics is that femoroacetabular impingement, FAI, accounts for most cases of idiopathic hip osteoarthritis[4]. FAI describes repetitive abutment between the proximal femur and the acetabular rim, due either to abnormal hip morphology or excessive hip motion, in patients with no childhood history of hip pathology[5]. FAI is estimated to affect 10-15% of the general population[6]. There are two types of FAI: *Cam impingement* occurs when a portion of the femoral head/neck junction extends beyond the typical spherical curvature, causing increased abutment of this portion of the proximal femur with the rim of the acetabulum. *Pincer impingement* occurs when a retroverted acetabulum results in linear contact between the femoral neck and rim of the acetabulum.

Symptomatic hip disorders associated with cam deformities are routinely treated with surgery, during which the deformity is resected in an effort to restore joint range of motion, reduce pain, and protect the joint from further degeneration. This is a technically demanding procedure and the amount of correction is potentially critical to the success of the procedure: under-resection could lead to continued progression of the osteoarthritis (OA) disease process in the joint, while over-resection puts the joint at risk for fracture. This study compares the accuracy of a new robotic-arm assisted technique to a standard open technique.

Methods: Sixteen identical sawbone models with a cam type impingement deformity were resected by a single surgeon (AR) simulating an open procedure. An ideal final resected shape was the surgical goal in all cases, figure 1. Eight procedures were performed manually using a free-hand technique and eight were performed using robotic assistance that created a three dimensional haptic volume defined by the desired post-operative morphology. All 16 sawbones and an additional identical uncut sawbone were scanned by a Roland LPX-600 Laser scanner with 1mm plane scanning pitch and 0.9 degree of rotary scanning. Post-resection measurements taken included arc of resection and volume of bone removed and were compared to the pre-operative plan, figure 2. Cutting times were also recorded. Paired t-tests were performed using Excel to measure statistical significance.

Results: The desired arc of resection was 117.7° starting at -1.8° and ending at 115.9°. Manual resection resulted in an average arc of resection error of 42.0 ± 8.5° with an average start error of -18.1 ± 5.6° and end error of 23.9 ± 9.9° compared to a robotic arc of resection error of 1.2 ± 0.7° ($p<0.0001$), an average start error of -1.1 ± 0.9° ($p<0.0001$) and end error of -0.1 ± 1.0° ($p<0.0001$). Over-resection occurred with every manual resection with an average volume error of 758.3 ± 477.1mm3 compared to an average robotic resection volume error of 31.3 ± 220.7mm3 (4 over- and 4 under-resected; $p<0.01$), table 1. Average cutting time for manual resection was 302.9±41.0 seconds and 209.5±16.0 seconds ($p<0.001$) for the robotic assisted resections.

Discussion: Even using an approach that maximizes visualization, robotic assistance proved to be significantly more accurate and less variable than manual techniques. This is critical as the success of the surgical treatment of FAI depends on accurate and precise boney resection. The benefits of this

new technique may prove even more valuable with less invasive, arthroscopic treatments that can be even more technically demanding.

Significance: Performing femoral osteochondroplasty for FAI treatment is technically demanding and proper execution of bone resection is a crucial part of the procedure that could benefit from a more accurate cutting system.

References

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