INTRODUCTION: Improper resection depth in the surgical correction of cam-type femoroacetabular impingement (FAI) has been identified as the most common reason for revision hip arthroscopy [1]. Under-resection fails to address patient symptoms and results in the need for revision arthroscopy [1], while over-resection may lead to iatrogenic femoral neck fracture, loss of the normal joint suction seal, or loss of congruency [2-4]. In our experience, removal of the sclerotic subchondral bone within the region of the cam lesion provides a simple method to guide the depth of resection (Figure 1), but quantitative data to demonstrate the suitability of this boundary does not exist. Using three-dimensional (3D) computed tomography (CT) reconstructions and statistical shape modeling (SSM), we determined whether removal of subchondral bone alone in the region of the cam lesion in FAI patients could produce femoral anatomy that was not significantly different than normal controls.

METHODS: Forty-five asymptomatic controls (29 males) and 28 cam FAI patients (26 males) of similar age, height and body mass index (overall mean±standard deviation; age 29±10 years of age; height 178.3±8.8 cm, and BMI 25.3±4.7 kg/m²; p>0.05 between groups for all metrics) gave informed consent for this institutional review board approved study. For each subject, 3D reconstructions of the inner and outer subchondral bone boundaries of the proximal femur were generated by segmenting CT images of the hip. SSM was applied to create mean shapes for each of the two groups [5]. The geometric difference between mean shapes was used to identify the region of the cam lesion. Subchondral bone in this region was removed from the 3D reconstructions of each cam femur to create a simulated resection. SSM was repeated with all control, native cam, and resected cam femurs to determine if the resection produced femoral anatomy that better resembled that of controls.

Correspondence particles from the SSM analysis were evaluated using principle component analysis (PCA). Significant (non-spurious) PCA modes of variation were identified using parallel analysis. The unpaired Student T-test was used to identify significant differences in modes of variation between groups. The distance from each correspondence particle within the region of resection to the same correspondence particle for the mean control shape was calculated, these distances were compared between groups using an unpaired Wilcoxon Rank Sum test. Finner’s method was used to correct for multiple comparisons. Surface distance between mean shapes was quantified in Preview (v1.18.1, FEBio Software Suite, University of Utah, SLC, UT), providing a node-based metric of the differences between mean shapes and visualization of these shape differences.

RESULTS: Prior to resection, ten PCA modes, which contained 87.0% of the overall shape variation, were determined to be significant. Of these ten modes, four represented significant differences between groups (p=0.024, 0.021, 0.023, and <0.001). The median [interquartile range] distance between the mean cam and control femurs in the region of the cam lesion was (median[interquartile range (IQR)]) 1.8[0.6] mm, with a maximum distance of 2.7 mm (Figure 2, left). Of the 133 particles within the region of resection, the distance to the mean control particles was significantly greater for the cam femurs than control femurs (1.8[0.7] vs. 0.0[0.1] mm; adjusted p<0.031 for all).

The resections resulted in maximum resection depths of 3.9[1.5] mm with a surface area of 1024±120 mm². Following resection, ten modes, which contained 86.8% of the overall shape variation, were determined to be significant. Of these ten modes, one described significant variation between groups (p=0.004), this mode aligned with the fourth significant mode for the native cam femurs. The difference between the mean resected cam and control femurs within the region of resection was reduced to 0.2[0.4] mm (Figure 2, right). The mean resected femoral exhibited 0.2 mm over-resection anteriorly and 0.9 mm under-resection superiorly. Of the 133 particles within the region of resection, no significant differences were found (0.3[0.4] vs. 0.0[0.1] mm; adjusted p>0.473).

DISCUSSION: While removal of subchondral bone alone did not fully restore anatomy due to the variations in shape of the medial femoral head and greater trochanter (Figure 1), the anatomy within the region of resection was not significantly different than controls after simulated resection. Based on these results, the sclerotic subchondral bone thickness can be used as a template for resection depth in cam FAI. On average, removal of subchondral bone alone in the region of the cam lesion resulted in 3D femoral anatomy that was within a millimeter of controls. Although the technique did tend to over-resect anteriorly and under-resect superiorly, the magnitude of these variations was submillimeter and not statistically significant. While clinical application of this technique requires proper definition of the region of the resection and observation of individual anatomy to ensure a properly contoured resection, the template for resection depth may help to reduce the occurrence of under- or over-resection in hip arthroscopy.

SIGNIFICANCE: Over-resection of a cam lesion may predispose the hip to femoral neck fracture or loss of the normal hip suction seal [2-4]. Under-resection is associated with persistent impingement related symptoms and continued joint damage [1]. Use of the subchondral-cancellous bone boundary may provide a straightforward template to define the depth of the resection during arthroscopic surgery.

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