Introduction:
In radial head arthroplasty, maintenance of long-term fixation and stem stability depends on multiple factors, including obtaining adequate initial stability and having an environment which promotes bony ingrowth. Previous micromotion analyses have demonstrated impaired interdigitation and formation of an impeding fibrous tissue layer with implant micromotion over 100-150 μm. Hoop stress fractures can potentially hinder prosthesis stability. No certainty exists as to what a surgeon should do if a crack develops during insertion of a radial head prosthesis. To our knowledge, there is no biomechanical study examining the implications of radial fracture during the insertion of a cementless radial head prosthetic stem. We hypothesized that an acceptable amount of micromotion can be achieved in the presence of cortical disruption during radial head prosthetic stem insertion.

Methods:
8 fresh frozen human radii without evidence of bony pathology were implanted with grit-blasted titanium stems. We tested 5 stem diameters, ranging from 6 mm to 10 mm in 1 mm increments. Our experimental protocol was designed to simulate actual intra-operative technique, and followed a stepwise insertion sequence. A custom-made slap hammer with removable weights was utilized. The weight options were 0, 0.75, and 1 kg, each of which was dropped from a height of either 0.1 or 0.15 meters. The mass and weights were increased until the rasp/stem was fully seated, or the radius fractured. The rasp or stem size which caused radial fracture was categorized as “oversized” (Max + 1), while one diameter increment below it was categorized as the maximum size (Max). Each rasp/stem size within a specimen’s testing sequence was assigned a label relative to the maximum. For instance, the following is an example of how we categorized a specimen which experienced cortical disruption at 9 mm: 6 mm (Max – 3), 7 mm (Max – 2), 8 mm (Max – 1), 9 mm (MAX), 10 mm (Max + 1). Prosthetic tip micromotion was measured using a custom-made device. The potted radius with the implant was rigidly fixed and two loads were pneumatically applied; a 100 N axial load and a 45 N radial load. A mounted laser displacement sensor recorded vertical displacement of the metal plate, and stem micromotion measurements were calculated using simple geometry. All data were analyzed using repeated measures ANOVA. All data are presented as mean ± SEM.

Results:
Of the 8 radii tested, 5 were analyzed for this study, as the maximally-sized rasp or stem failed to achieve cortical disruption in 3 of the specimens. The mean insertion energy of the oversized rasp (17 ± 3 J) was more than two-fold greater than that of the maximally-sized rasp (7 ± 3 J) (p ≤ 0.05). A similar relationship was seen with the maximally-sized stem (3 ± 2 J) and the oversized stem (7 ± 4 J) (p = 0.15). Stem tip micromotion decreased with increasing stem diameter. The oversized stem demonstrated the least micromotion (23 ± 5 μm) of all the diameters tested. In all 5 of the specimens, the oversized diameter stem exhibited micromotion measurements below 100 μm, with the greatest micromotion observed being 32 microns. All 5 specimens implanted with maximally-sized stems also exhibited micromotion measurements below 100 μm, with the greatest observed micromotion being 35 microns. The micromotion measurements for the maximally sized stem (24 ± 5 μm) and oversized stem (23 ± 5 μm) were both below 100 μm and a means contrast comparison revealed that they were not statistically different from each other (p = 0.93).

Discussion:
Our study demonstrated that an acceptable level of prosthetic radial head stem micromotion can be achieved when the radius is fractured during prosthetic stem insertion. This suggests that ‘over-rasping’ in the setting of radial head replacement may not require reinforcement or fixation. Controversy exists regarding how to manage similar fractures in hip replacement. Based on our study, the appropriate decision may be to leave the stem in if a crack occurs in the final stages of radial head stem insertion. This would preclude the need for placement of unnecessary hardware or performing additional procedures during the case. Furthermore, surgeons may be able to avoid additional post-operative considerations that typically follow iatrogenic fractures during arthroplasty, such as extended antibiotic administration, prolonged immobilization of the joint, and delayed rehabilitation. Recent biomechanical studies demonstrated that submaximally-sized and maximally-sized stems both achieve acceptable levels of micromotion. This biomechanical investigation provides us with another viable option of radial head stem size, the oversized diameter.

One limitation of this study is that cadaveric radii were used for biomechanical analysis. A disadvantage of this is the inability to monitor in-vivo effects of the fracture on stem ingrowth. For instance, the physiological effects of the injury on implant fixation, by they positive or negative, can obviously not be assessed in this model. Another limitation is that this does not take into account the viscoelastic stress-relaxation of bone, which takes time.

In conclusion, in the event of cortical disruption during radial head prosthetic stem insertion, the implant can retain a biomechanical environment conducive to adequate initial stability and bony ingrowth comparable to non-fracture circumstances.

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