Stem Diameter and Fixation Strength of Press Fit Radial Head Prosthesis
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Introduction:
Clinical studies suggest that failure of radial head prosthesis can be due to loosening or inaccurate restoration of radial length. Aseptic loosening of the stem, ranging from mild periprosthetic lucency to symptomatic loosening leading to implant removal, has been reported in press fit radial head prostheses. Previously designed monoblock prostheses, which have been intentionally inserted loose to allow them to function as a spacer, may have been an important factor in the development of the lucencies. Initial stability of the implant-bone interface is, as with other arthroplasties, important for long term clinical success. Proper stem size and sufficient bony contact are important to obtain secure fixation, which restricts excessive micromotion that may reduce or inhibit bone ingrowth. There are no biomechanical studies specifically addressing the effect of stem size on initial stability of the radial head prosthesis. Furthermore, little data exists on the techniques specifically addressing the effect of stem size on initial stability of the radial head prosthesis. The purpose of this study was to determine the effect of the stem diameter in achieving initial stability with a press fit radial head prosthesis.

Methods:
Sixteen (eight paired) fresh frozen cadaveric radii were implanted with non-cemented radial head prosthesis that has a straight titanium stem. Five different diameters (6, 7, 8, 9, 10 mm) of implant were inserted while measuring the force required for insertion of each rasp and real stem respectively in a material testing machine. Stem diameters were determined by X-ray measurement of medullary canal of radial neck before testing. After measuring the insertion forces up to the planned size of stem, micromotion between stem and bone interface was measured by a custom made laser displacement device (Fig. 1). This was done under eccentric compression loading in four different loading areas (anterior, posterior, medial, lateral). The maximum insertion force and degree of micromotion of each size of all specimens were compared with a use of repeated measures analysis of variance. A matched pair test of micromotion between the maximum and submaximal stem sizes was performed. In addition, correlation between the maximal insertion force and micromotion was assessed. A selected appropriate size of each specimen was confirmed to optimality after experiments. Maximum diameter was defined as the largest diameter of stem which for the corresponding rasp did not fracture the bone. Submaximum diameter was defined 1 mm less than maximum diameter. All data are presented ±1 standard deviation.

Results:
In five specimens, the 10 mm rasp fractured the bone during the rasping procedure. For these specimens, a 9 mm diameter was defined as the maximum diameter and 8 mm was defined as submaximum. Three other specimens had 8 mm maximum diameters and 7 mm submaximum diameters. The maximal insertion force was recorded when rasps were inserted fully. Mean maximal insertion force of each size of rasp was significantly different. Compared to submaximum sized rasps (144 ± 89 N, p < 0.05) and oversized rasps (683 ± 152 N, p < 0.0001), the maximum sized rasps (278 ± 152 N) had significantly different maximal insertion forces. The maximal insertion force of each stem was lower than that of the same size rasp. The maximum sized stem (200 ± 97 N) showed higher insertion forces than the submaximum sized stems (105 ± 75 N) (p < 0.01) (Fig. 2). Mean micromotion in the maximum diameter stem size (48 ± 25 µm) was significantly less than that in submaximum size stem (294 ± 150 µm) (p < 0.01) (Fig. 3). No difference was seen based on different loading areas. A reverse correlation between the insertion force of stem and micromotion was found (Spearman’s ρ = -0.66, p = 0.005).

Discussion:
When obtaining press fit fixation, initial stability of radial head prosthesis was related to the diameter of stem. Our data of micromotion suggested 1 mm difference of stem size was critical to achieve stability. Maximum sized stems had significantly less micromotion under all applied loads with an average of 25–75 µm, whereas the micromotion of submaximum sized stems exceeded 250 µm. A reverse correlation between the stem insertion force and micromotion implied that insertion force of the rasp and stem predicts micromotion of the prosthesis. Limitations of this study include that only one design of radial head prosthesis was tested. There are different stem designs, lengths and surfaces on the market and all these characteristics may affect the stability of the stem. Another limitation is that these results were obtained from elderly cadaveric radii. Bone quality can affect stability for press fit cementless implants. But, we used paired bone to reduce the effect of bone quality of specimens. In conclusion, maximum diameter stem achieved greater stability when compared to submaximum diameter stem. The best fixation strength in press fit radial head prosthesis was achieved by maximum sizing in the neck canal.

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Fig 1: Custom made laser displacement device for measuring micromotion

Fig 2: Average maximal insertion force for the rasp and stem by diameter (Max = maximum, Max-n = n mm less than maximum size, Max+1 = 1 mm larger than optimal size). Lowercase letters indicate the results of Student-Newman-Keuls post-hoc testing (p < 0.01). Columns with a the same letters are not statistically different (Rasp and Stem values are not compared to each other in this figure).

Fig 3: Average micromotion for the submaximum and maximum size stem (*p value for difference < 0.01).