Biomechanical Strain Distribution Difference and the Effect of Low Bone Density on Two Major type Stemless Shoulder Arthroplasty

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<u>Introduction:</u> There are several design options available for humeral implants of shoulder arthroplasty. In recent years, there has been a growing trend towards the use of stemless designs to protect bone reservoirs and reduce stress on the shoulder. Stemless implants improve preservation of bone tissue, decrease shielding caused by stress, decrease surgical time with less blood loss, and provide simpler removal during revision procedures. Stemless arthroplasty has the potential to provide a more reliable anatomical reconstruction of the humerus since the placement of the artificial head is precisely centered inside the humeral section, irrespective of any misalignments in the shaft and metaphysis. There are two types of more conventional stemless shoulder arthroplasty implants available. The first category, as described by Zimmer-Biomet, consists of a central tapered region and six outer wings. The second category from Equinoxe involves an implant that is secured by compression in the metaphyseal region of the humerus bone. A biomechanical cadaveric model was used, where numerous physiologic load cycles were applied, to conduct a comparative analysis of the two implant types in specimens with low bone density, which often exhibit higher levels of micromotion. The main purpose of this study was to achieve two objectives: 1) to assess and compare the maximum normal strain in different regions between two distinct designs, and 2) to evaluate the impact of low bone density on these two designs, particularly in relation to the occurrence of maximum micromotion under the highest applied loads. By using load distribution and micromotion analysis, this research provides surgeons with supporting data for stemless arthroplasty usage in patients with poor bone density.

<u>Methods:</u> Two types of implants were surgically inserted into cadaveric shoulders (N=20). Implants tested were the Stemless Shoulder from Equinoxe and the Comprehensive Nano Stemless Shoulder from Zimmer Biomet. All samples underwent dual-energy x-ray absorptiometry (DXA) to document bone density. Humerus with implant were completely dissected and prepped for Three-dimensional Digital Image Correlation DIC strain measurements. Following dissection, white paint was uniformly sprayed onto the samples, followed by the addition of black paint speckles with an airbrush. The samples were securely affixed inside a custom-designed jig and inclined at an angle of 15 degrees in the coronal plane to exert force in parallel with the axis of the implant **(Fig. 1-1)**. Samples underwent cyclic loading (Instron) with the cadaveric samples were subjected to analysis, whereby the maximum normal stresses and micromotions were retrieved from each individual specimen. three distinct loads each repeated for a total of 100 iterations, similar to prior investigations. 220N, 520N, and 820N loads were used to represent preconditioning, a conservative estimate of post-operative shoulder loading, and the peak loading during "normal" use with no weight in the hand. After cyclic loads, samples were loaded to failure to find the failure load and its location. The digital image correlation system (LaVision Inc, Strain Master) was used to estimate the maximum normal strain and micromotions at three distinct sites selected based on visual indications of failure, namely the implant, bone, and fracture sites.

<u>Result Section:</u> After conducting a thorough examination of normalcy using the Shapiro-Wilk test, any possible outliers were carefully identified and then eliminated from the individual sample results. In the next step, we conducted a thorough analysis using either a paired T-test or a Wilcoxon matched-pairs test, depending on the normality of the data. This analysis aimed to examine the accumulated data from two different implant variants in detail. In general, the strain in all three locations (Implant, Bone, and fracture site) exhibited a rise when the load was progressively raised from 220 to 820. Notably, the fracture site strain showed the greatest values, while the implant strain exhibited the lowest values (**Fig. 1-4, 1-2**). Results showed that no statistical significance was seen in any of the tests conducted using the Wilcoxon matched-pairs signed rank test and Paired t-test. Comparisons have been made between micromotions in the aforementioned three locations and the tracking of movement in three dimensions. The resulting data has been subjected to analysis using the same methodology. The presented data illustrates the micro strains and micro-movements occurring in the bone area when subjected to a load of 520N for both samples of implants (**Fig. 1**)

<u>Discussion:</u> Several studies have been undertaken to compare the mechanical features of various brands of shoulder arthroplasty stems. Many investigations encounter challenges due to variations in bone density and size. In order to enhance the precision of our comparison, we used ten pairs of humerus bones obtained from ten cadavers. We conducted DXA to compare the bone densitometry of samples, therefore mitigating the potential influence of variations in bone properties as a confounding variable. This work is the first cadaveric biomechanical investigation comparing the stemless Equinoxe with the Nano Stemless Zimmer Biomet hemishoulder arthroplasty. The findings of our investigation indicate that there was no statistically significant disparity seen in terms of micromotion and failure point between the two groups.

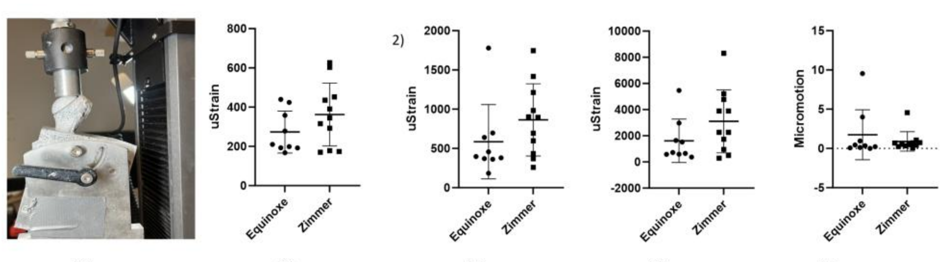

Figure 1: (1) A side view of the testing setup showing the fixation of bone in Instron. Comparison of Micro Strains in both implants at (2) Implant, (3) Bone, and (4) Fracture site, respectively. (5) Micromotion of the bone region under the post-operation load for both implant types.