INTRODUCTION: Modular hip prosthesis, utilizing Morse taper technology, were introduced into joint replacement around late 1970's. The interlocking tapered shaft and head allow for quick and simple connection of mechanical parts. The two parts are held together by the friction created by forcing a tapered shaft into the tapered socket. Utilization of the Morse taper in modular hip prosthesis has many clinical advantages. These include the ability to use different size and material for head and stem, decrease in inventory size and cost and ability to perform trial reductions and the stem has been implanted. This allows for leg length adjustment during primary surgery. During revision surgery, Morse tapers allow the isolated exchange of the head or neck in the case of a well fixed stem and increased exposure during acetabular revisions by removing the head.

Recently there has been increasing concern with the clinical use of Morse tapers. The successful performance of an implanted Morse taper is believed to depend on many variables. Some of these variables include manufacturing tolerances, materials used and design parameters. Intra-operatively, debris such as blood, fat or pieces of bone can accidentally land on the taper surfaces. Although most surgeons make an effort to maintain the surfaces clean, there are very few studies that address the effects of biological debris in the mechanical behavior of modular implants. Our objective is to assess the effects of assembly force and biologic debris within the taper interface on taper disassembly forces.

METHODS: A jig was constructed to simulate the impaction of a head on a stem. Eight orthopedic surgeons with different levels of training and experience were asked to participate in the study. The setup consisted of a ring strain-gage load cell placed in a horizontal position. The surgeons were told to simulate the motion and strength used intraoperatively to assemble modular hip prosthesis. Each surgeon practiced three blows and the peak force of the next five blows after that was recorded. The age, height, weight and number of years since graduation from medical school was also recorded for each surgeon. The average of the five recorded blows for each surgeon was calculated. From those values a distribution was obtained for the eight surgeons. From the force distribution of the above simulation three values were picked. The mean force and two standard deviations above and below the mean were selected. Four tapers were then assembled at the mean impaction force, three tapers at two SD below and two SD above. A drop tower was used to ensure repeatability of the force. All ten tapers were then disassembled using an MTS with a load rate of 0.05 mm/sec. The force necessary to disassemble these tapers was recorded and compared to the impaction loads. The impaction and disassembly were then repeated four times for each taper.

The second portion of this study assesses the effects of biologic debris on disimpaction. Recently there has been increasing concern with the clinical use of Morse tapers. As mentioned above, debris such as blood, fat or pieces of bone can accidentally land on the taper surfaces. Although most surgeons make an effort to maintain the surfaces clean, there are very few studies that address the effects of biological debris in the mechanical behavior of modular implants.

RESULTS: The average ±SE impaction force (in Newtons) achieved by the eight surgeons was 1661 ± 148 SE N, with a range of 893 - 2377 N. The average ±SE age of our surgeons’ group was 37.5 ± 2.87 SE years old. The average ±SE height was 70 ± 1.40 SE inches. The average ±SE weight was 187 ± 11.35 SE lbs. Age, height, weight and level of training had no statistical correlation with the impaction force in Morse tapers. The impaction force, however, had a strong linear correlation (r = 0.963) with the disassembly forces. On the initial assembly/disassembly cycle, there was no statistical difference between the 3 groups in the force required for removal of the head (Figure 1). On the second, third and fourth cycles, disassembly forces for the tapers with blood and fat were statistically significantly lower from those measured for the clean tapers and the tapers that were wiped with gauze (p < .001). The clean tapers and the tapers wiped with gauze did not show any statistically significant difference between any of the 5 repeated disassemblies (p = .871, p = .779). For the tapers covered in fat and blood, there was a significant difference between the first disassembly force and the second, third and fourth disassembly forces (p = .46, p = .006 and p = .010). The mean force for the first disassembly on the fat and blood covered tapers was 1654 N. The mean forces for the second, third, fourth and fifth disassemblies were 703 N, 421 N, 466 N and 779 N respectively.

CONCLUSIONS: Our data shows that the forces used in impacting a head on a trunnion have significant variability. Surgeon's age, training, and body mass index have no effect on the required impaction force. Impaction force, however, significantly affects the disimpaction forces required to remove the head from a trunnion. It is evident from our data that by applying higher impaction forces a better bond between the trunnion and head can be achieved. Lower impaction forces during the surgical procedure could result in increased micromotion between the head and taper junction in total hip replacements. Our data also shows that preparation of the taper surface has a significant effect on disassembly forces. On the initial assembly trial, there was no statistically significant effect. However, on multiple assembly/disassembly cycles, such as those encountered in revision surgeries or in cases in which the surgeon initially impacts the incorrect head size, the contamination of blood and fat can have a significant effect on disimpaction. The larger disassembly forces required are associated with a tighter fit. If a tighter, stronger fit is achieved, decreased micromotion and fretting of the taper interface may result in a longer prosthetic life. We recommend that during total hip replacements, an effort be made to keep the surface clean of debris. Before assembly, surgical gauze should be used to clean the taper surface thoroughly. Finally, an attempt should be made to achieve the highest impaction force possible during assembly of the head on the stem.