5.4 Recommendations for Maximizing Range of Motion

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With the dawn of the new Millennium, Hip replacement surgery entered a new era of expanding indications and technological improvements which seek to further optimize one of the most successful interventions of modern medicine. In the beginning, there was the low friction arthroplasty. John Charnley recognized that synthetic materials did not have the very low wear demonstrated by articular cartilage. For that reason he moved away from the large ball heads that were part of normal human anatomy. Because his technique often resulted in a transposition of the greater trochanter, pain relief and stability along with a protected sedentary lifestyle were the keys to successful outcomes. He was a master at limiting patient expectations and reserving the procedure for the low demand elderly. The leg length discrepancies and other biomechanical alterations were much welcomed trade offs for the comfort and function improvements that were a result of hip replacement. It changed many people's lives. However some 4 decades later, we are faced with a much different situation. Hip replacements are very successful and surprisingly durable. Hip disease in the younger and more active elderly is best treated with this procedure, as no other intervention is able to restore the comfort and function of these patients so reliably. In addition, trauma and osteonecrosis continue to afflict many younger individuals who need to work and raise families. Once again, hip replacement stands alone in its ability to restore comfort and function for the long term.

We have become victims of our own success. With many studies boasting over 95% good to excellent results at 10 years and beyond, surgeons and patients continue to push the activity envelope after hip replacement. Patients undergoing hip replacement surgery are more active than originally thought, with the average patient having over 2 million cycles per year [1]. Polyethylene wear directly correlated with activity, and there is a strong trend toward a much more active elderly population with a long life expectancy. These patients are engaging in activities far more strenuous than just walking. They wish to play with their children or grandchildren (often on the floor), or return to their jobs, many of which are also strenuous. The demands of life, financially and philosophically, are pushing patients to feel more "normal" with their hip replacement, rather than "disabled".

With this in mind, the need for a more functional and durable total hip has developed. With wear the biggest problem faced by surgeons, and polyethylene debris recognized as the main culprit, the standard head size remained at 28mm, a balance between the low volumetric wear but high linear wear of the 22mm ball head and the high volumetric, low linear wear of the 32mm ball head. There was a strong desire to use 32mm ball heads as it represented the smallest size where bony, as opposed to prosthetic impingement was the main source of instability [2]. (Fig. 1) This balance between optimizing wear and stability has always been a difficult one.

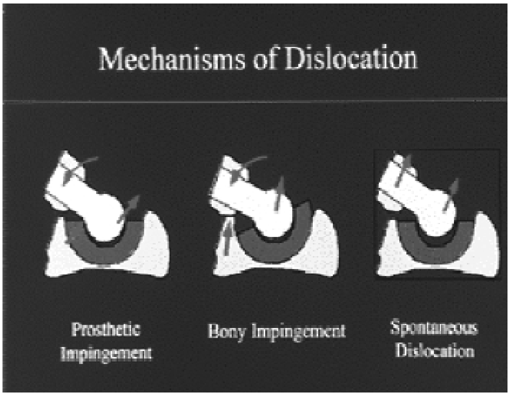


Figure 1a:
Mechanisms of dislocation.

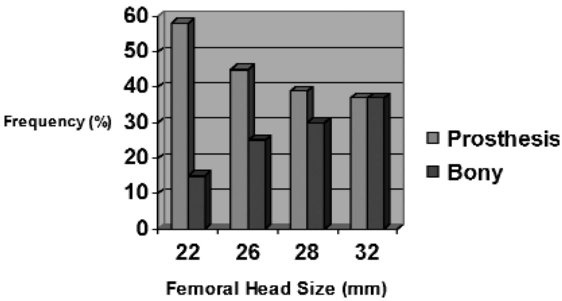


Figure 1b:
Head Size vs. Site of Impingement.

But fortunately, technology continues to modify and improve our devices and with the development of advanced bearings, low wear even for large ball heads is now a reality for both metal-on-metal and ceramic on ceramic systems. Highly-crosslinked polyethylene is also showing some promise in the lab, but longer-term clinical studies are not available and there remain some questions about the amount of crosslinking and subsequent strength reduction of the material. This is particularly true as ball head sizes enlarge, as care must be taken to maintain a sufficient minimum thickness of poly in all areas of the system.

Maximizing the range of motion for optimization of patient function and minimizing instability following total hip replacement therefore has a few key considerations:

1. Maximizing the size of the ball head.
2. Using a favorable neck geometry
3. Avoiding elevated metallic rims on acetabular components
4. Proper component placement
5. Choose proper bearing materials
6. Avoid bone and soft tissue impingement.
7. Counsel and educate your patient

1. Maximizing the ball head Size. There is no question that the easiest way to improve function and minimize instability in total hip replacement is to eliminate prosthetic impingement of the femoral neck and acetabular component. Studies have shown that the maximum range of motion obtained by any system increases with increasing ball head size [3]. (Fig. 2). In choosing a large ball size,

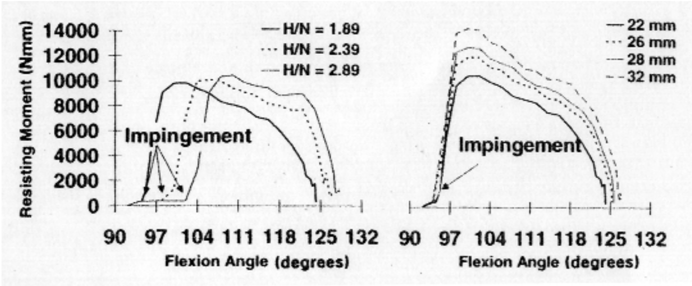
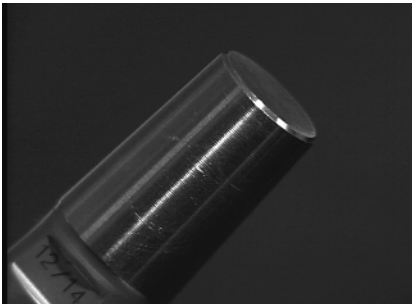


Figure 2:
ROM as a function of Ball size. [3]

which is now available from multiple manufacturers in 36mm and even 40mm varieties, the bearing surface must be considered. Ceramic on Ceramic systems have some limitations in terms of ball lengths, but the bearing surface has been well investigated over 30 years and remain the lowest wear couple currently available. Risk of ball fracture also decreases with increasing ball head size. The extremely low wear with hard on hard systems eliminates all concerns regarding the theoretical increased volumetric wear with increased ball head sizes [4].

2. Much attention in recent years has been paid by prosthetic manufacturers with respect to optimizing neck geometry for further improvements in range of motion without compromising strength. More trapezoidal geometries with shortened tapers have enhanced this aspect of hip replacements [5]. (fig. 3).



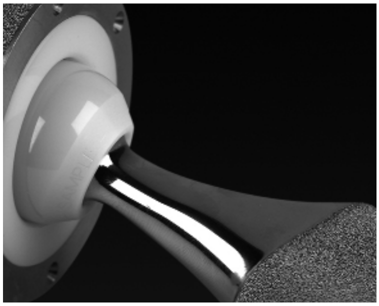


Figure 3:
3a: Old style neck geometries, long and wide. 3b: Streamlined neck geometry example.

3. Any elevation of the cup rim to protect the bearing surface may lead to slightly reduced range of motion as well as mode 4 wear and additional metal debris release if impingement were to occur post-op. With reports of potential problems of these types of designs, consideration for other designs is recommended [6].
4. Proper component placement is by far the most critical aspect of optimizing range of motion. Most studies concur that 45 degrees of flexion is the ideal, balancing the need for significant flexion while limiting wear and stress overload. In addition, anteversion of both the stem and the cup play important roles in optimizing the functional range of motion and stability of the total hip replacement. Femoral anteversion of 15 degrees and acetabular anteversion of 15-30 degrees are also recommended [7]. (Fig. 4). Proper placement of the

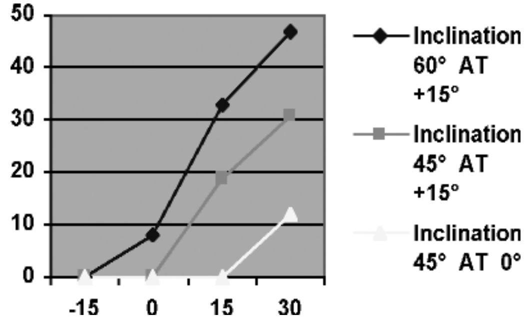


Figure 4:
Range of Motion in internal rotation at 90 degrees of flexion as a function of cup inclination and anteversion.

components has its pitfalls. In the lateral position the patient has an increased lumbar lordosis as the pelvis has a tendency to flex on the table. When it extends in the upright position, there is relatively reduced anteversion. Also, in the lateral position, the pelvis can have a tendency to tip forward, unbeknownst to the surgeon, also resulting in lost anteversion. Trial reduction with trial liner is critical in assessing all-important parameters including leg length, offset and stability. Navigation, or computer assisted surgery, is being developed and reaching the point where it may soon add valuable feed back to the surgeon regarding optimal cup placement.

5. Larger ball heads, as mentioned above, can result in an increased head/neck ratio. This can minimize or eliminate impingement in the normal range of motion zone. However, in order to reduce wear with these larger heads, a hard on hard bearing surface is recommended. Ceramic-ceramic couples have the lowest wear while remaining bio-inert to reduce risks to patients and optimize longevity. (Fig. 5)

Figure 5:
Increased ROM as a result of larger ball head, improved neck geometry and a ceramic-ceramic couple. (Courtesy of Wright medical technology).

6. Occasionally osteophytes and scar tissue will create impingement points. These tissue impingement points need to be evaluated and reduced with appropriate removal of bone and soft tissue as necessary to minimize this form of impingement.
7. Patient education remains the final key for success. Patients, if they try hard enough, can damage any device that is implanted. Patients must be educated on the limitations of these devices and they should strive to remain within those limitations. Extreme range of motion activities should be discouraged. Patients are encouraged to use their hip replacements, not abuse them.

In Summary, hip replacements continue to evolve and with new techniques and materials, one can continue to meet the increasing demands that are placed on these devices. Proper placement of components coupled with large heads and ceramic bearing materials can optimize the hip replacement for function and longevity for the most active patient.

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