Introduction

Total joint replacement surgery has given many patients relief from joint pain as well as great improvement in their level of function. It has become one of the most successful and frequently performed orthopedic surgeries. Over the past few decades, it has evolved greatly due to improvements in materials, prosthetic joint designs and surgical techniques. A recent trend towards minimally invasive arthroscopic, laparoscopic and angioplastic surgeries has triggered an interest in the development of minimally invasive total joint replacement surgical techniques. These surgical techniques are designed to allow a total joint replacement of the hip or knee through a smaller incision with potentially less tissue damage. Proponents of minimally invasive surgery believe that these new techniques hold the promise of decreased tissue damage, blood loss and post-operative pain, as well as faster post-operative recovery, shortened length of stay and improved cosmetic results due to a smaller scar. Skeptics of these new techniques worry about the addition of new risks to an already very successful surgery, poor visualization during the procedure, increased difficulty of the technique and a possible increase in operative time [1]. This chapter will discuss the effects minimally invasive total joint replacement surgery may have in the rehabilitation process and outcomes of patients undergoing total joint replacement surgery.

Developments in Total Joint Replacement

At the beginning of the 19th century, several surgical treatments of the painful hip were attempted, such as osteotomies and implantation of interpositioning materials, including soft tissue, wood and gold foil. The first attempt at a total hip replacement was performed by Wiles in 1938. Charnley introduced the use of a metal femoral head and a high-density polyethylene, reporting a 96% success rate at 10-year follow-up in 1973 [2]. Currently, total joint replacement surgery through the standard posterolateral, lateral and anterior approaches is extremely successful. Total hip arthroplasties have increased from 80,000 yearly procedures in 1976, to 125,000 in 1993 and approximately 250,000 currently [2, 3]. These numbers are expected to increase considerably as the “baby-boomer” generation reaches the age of peak incidence of debilitating osteoarthritis. Individuals in this very physically active generation will also have very high expectations of their functional status after total joint replacement. Many of them will not be satisfied with short-distance ambulation and transfers, but instead will expect the ability to participate in more challenging physical and athletic activities. The challenge for prosthetic designers, orthopedic surgeons and rehabilitation specialists will consist of helping this generation achieve its goals.

Not only have total joint replacement surgical techniques, prosthetic designs and materials improved greatly over the past few decades, but the rehabilitation process has changed considerably as well. There has been a trend to initiate therapy and improve pain control, strength and ROM earlier in the rehabilitation process. The introduction of cemented prostheses allowed earlier weight-bearing, sometimes as soon as the first or second post-operative day. A report from the Hospital for Special Surgery from 1990 to 2000 showed a trend to earlier achievement of functional milestones after total hip arthroplasty. In 1990, total-hip-arthroplasty patients were able to achieve unassisted transfers, walker ambulation and stair climbing in a mean of 7.7 days. By the year 2000, these goals were achieved in a mean of only 4.4
days. The length of stay was also reduced from a mean of 9.7 days in 1990 to 5.3 days in 2000 [4]. Advocates of minimally invasive joint replacement surgery purport that these less invasive surgical techniques will further shorten the time to achieve functional goals and length of stay.

Principles of Joint Replacement

The current principles of joint replacement consist of early pain control, mobilization, range of motion and functional training, including independent transfers, ambulation with gait aids, stair climbing and activities of daily living. Pain control is crucial not only for patient comfort, but also to ensure better participation and gains during therapy. Early mobilization and institution of range of motion exercises post-operatively are also essential. Range of motion is usually started immediately post-operatively and ambulation commences approximately 1 to 2 days post-operatively. Precautions must be maintained during the rehabilitation process, especially in hip arthroplasties to avoid dislocations due to capsular weakness from the necessary surgical disruption of the capsule. After posterior approaches, care must be taken to avoid hip hyperflexion or internal rotation and after lateral approaches hip adduction and internal rotation must be avoided.

One of the main goals of minimally invasive joint replacement surgery is to decrease the amount of surgical trauma and tissue damage. Many different techniques and approaches have been described for both the hip and knee. During standard posterior approach to the hip, a long incision is made, the gluteus maximus is split along its fibers and the external rotators of the hip are detached from their femoral insertion [5]. Although many different minimally invasive posterior approaches have been described, the dissection of the gluteus maximus is much smaller and not always are all the external rotators of the hip detached from their femoral insertion [5]. Although many different minimally invasive posterior approaches have been described, the size of the incision is determined by the space necessary to safely insert the acetabular component. During total knee arthroplasty, minimally invasive techniques strive to maintain the integrity of the extensor mechanism and the suprapatellar pouch, which are many times violated in the standard approach [8]. Preserving muscle integrity will be very important to the patient who hopes to continue to participate in high demand activities. By eliminating the need to recover the function of these muscles, the patient can more quickly progress to higher level rehabilitation, such as proprioceptive and plyometric training, with the goal of maintaining high-level function while muscually controlling joint forces and potentially protecting these prosthesis from early wear and failure.

Pain Management

Minimizing tissue damage from surgical trauma has the potential effect of reducing post-operative pain which is also a major goal of the minimally invasive surgical procedures. A decrease in pain levels can be expected with smaller skin-and soft-tissue incisions. A reduction in pain can positively affect rehabilitation at many different levels. Firstly, by reducing the amount of pain, the patient may be able to better participate in therapy, ensuring a decrease in missed sessions secondary to pain, as well better performance and attention during each session. By reducing the amount of medication necessary to control pain, the known side effects of pain medications, such as decreased alertness, sleepiness, nausea and constipation, among others, can be minimized. All these side effects can have a negative impact on the participation and gains during the rehabilitation of post-joint arthroplasty patients. Another deleterious effect of pain on the rehabilitation process is weakness of the muscles surrounding the affected joint secondary to pain inhibition. The weakness caused by pain inhibition not only affects functional gains due to weakness during functional activities, but also causes muscle imbalances across the joint. These muscle imbalances and weakness can result in altered biomechanics which can result in antalgic gait patterns. For example, pain inhibition of the quadriceps (especially the vastus medialis) results in a quadriceps avoidance gait. This again results in altered biomechanics and neuromuscular engrams which can be difficult to retrain or eliminate, even after the pain has disappeared.
Currently, to our knowledge, there are no published studies that compare the level of pain between a standard and a minimally invasive joint-replacement surgery as one of the measured outcomes. Nevertheless, many surgeons anecdotally report decreased pain levels with minimally invasive techniques [1, 3]. Although a reduction in pain is expected with the decrease of tissue trauma achieved with these procedures, further prospective randomized studies with pain levels as a major outcome measure will be helpful to further elucidate this issue.

**Joint Stability**

Another advantage of preservation of muscle tissue integrity during joint arthroplasty is to reduce the amount of mechanical derangement of the main joint movers and stabilizers. This should result in better preservation of strength, and biomechanical stability around the joint. By maintaining closer to normal biomechanics and joint stability, quicker achievement of functional milestones can be expected. During hip replacements, the capsular incision still has to be large enough to accept the acetabular component, and thus there is still a risk of dislocation through the capsular violation. For this reason, the usual precautions still must be maintained. Nevertheless, improved biomechanical stability due to better preserved stabilizing musculature may reduce the inherent risk of dislocation. On the other hand, component malposition has been correlated with an increased risk of dislocation. Skeptics of the minimally invasive techniques worry about the increased difficulty in prosthetic positioning, the inability to eliminate osseous impingement and osteophytes and the inability to thoroughly assess stability due to decreased joint exposure. All these difficulties may result in component malposition, prosthetic joint instability or increased risk of dislocation [1]. However, Kennon et al. reported 28 dislocations in 2132 patients (1%) during the first 6 months after total hip replacements done through a minimally invasive anterior approach which is no greater than the normally quoted 1–2% for the standard approaches [7].

**Mobilization**

As discussed earlier, over the past decade, the number of days to achieve functional outcomes and to discharge has decreased significantly. Physical and occupational therapy are started earlier and more aggressively. Discharges as early as 3 days post-operatively are not uncommon. Minimally invasive total joint replacements are expected to reduce the amount of time needed to achieve functional milestones and thus reduce the length of stay. By decreasing tissue damage, post-operative pain and post-operative weakness, this type of procedure promises a quicker rehabilitation process. Some advocates of minimally invasive surgery believe that patients may leave the hospital within 24 hours of the operation. Berger implemented an accelerated rehabilitation protocol for his patients after a minimally invasive two-incision approach. Patients were allowed to leave the same day or the day after surgery as long as they met the discharge criteria. The criteria required the patient to transfer in and out of bed from a standing position, transfer from a sitting to standing position, walk a minimum of 100 feet and ascend and descend a full flight of stairs. Out of 88 patients, 100% were discharged to home during the first 23 hours. Eighty-five percent were discharged the day of the surgery and 15% were discharged the next day [3]. The benefits of early discharge to home are obvious in terms of both cost effectiveness and patient satisfaction. This type of accelerated rehabilitation with early discharge to home requires attention to the patient’s home situation and well-coordinated services, especially in the older, single and medically complicated patient.

The early mobilization that may be achieved by minimally invasive procedures may also have a positive impact in other areas of rehabilitation. By facilitating early ambulation, common complications of inactivity such as muscle atrophy, neuromuscular and cardiovascular deconditioning, constipation, ileus, pneumonia, decubitus ulcers and deep venous thrombosis may be avoided.

**Complications**

Deep venous thrombosis is a relatively common complication of total joint replacements with a prevalence quoted between 5% and 60%. This is felt to be secondary to local trauma of the vascular endothelium during surgery, potential hypercoagulable states after tissue trauma and venous stasis secondary to inactivity. Kennon et al. report a 0.8% incidence of clinically relevant thromboembolic disease in their series of 2132 minimally invasive total hip-arthroplasty surgeries through an anterior approach.
All their patients were prophylaxed with a 65 mg daily dose of aspirin. They believe that their low number of thromboembolic events are due to short operative times, avoidance of femoral vein retraction and improved limb positioning, achieved with their anterior approach [7]. It should be noted that in this series only clinically relevant thromboembolic events were reported, thus, non-clinically relevant deep venous thrombosis were not looked for or reported. Even though, early mobilization is not enough to prevent deep venous thrombosis by itself, in combination with the usual prophylaxis, it may help reduce the incidence of this common complication.

**Conclusions**

Total joint replacement surgeries have evolved greatly over the past few decades, and minimally invasive techniques represent the newest development in this highly successful surgery. By reducing the initial trauma at the time of surgery, the benefits include: less tissue damage, reduced pain, faster rehabilitation with earlier accomplishment of functional outcomes, decreased length of stay and possibly reduced complications resulting from immobilization. An ever increasing, more active and demanding patient population will be seeking these very promising techniques for both short- and long-term effects on function and quality of life.

**References**