Indications for Total Hip Arthroplasty and Selection of Prosthesis

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Abstract: The initial clinical success of total hip arthroplasty was confirmed more than 30 years ago and it is now considered as one of the most useful orthopedic procedures. With regard to the long-term outcome of this surgery, the 20-year prosthetic survival is 83% and 10-year survival rates of almost 100% have occasionally been reported. New hip replacement prostheses are still being developed, but the use of a new prosthesis requires adequate knowledge and caution because its value can only be established after testing for more than ten years and it is not uncommon to find new defects during the testing process. To select a prosthesis, various factors should be taken into consideration, including the method of fixation (cemented or cementless), the combination of articular surfaces, the quality and morphology of the patient’s bones, and the surgeon’s experience. When the patient is young, it is important to consider total hip arthroplasty as part of a long-range therapeutic plan including revision arthroplasty, which can follow a course of over 30 years.

Key words: Total hip arthroplasty; Indication; Bone cement; Polyethylene; Component

Introduction

Charnley’s original total hip arthroplasty procedure, developed about 35 years ago, was a breakthrough on which the current success in this field depends (Fig. 1). Charnley placed priority on the development of low-friction surfaces that allowed articular motion with a low torque and called his prosthesis a low-friction arthroplasty. The design that he created was typically a combination of a small femoral head (about 22 mm in diameter) and a polyethylene socket. He also developed various revolutionary surgical techniques for the performance of arthroplasty, leading to clinical success. Subsequently, many other types of prosthesis have been developed for total hip arthroplasty, with the aim of achieving better results. These prostheses were improved in some...
respects, but many of them were eventually abandoned because new drawbacks were detected.

Even more than 30 years after Charnley’s success, new prostheses are continuously being developed. A surgeon who wants to use such a new prosthesis should select it on the basis of extensive knowledge and must exercise caution, because the testing for more than 10 years that is necessary to assess its clinical value has not usually been completed. Therefore, it is not rare for different surgeons to choose different prostheses for the same indication even if the selection is based solely on consideration of functional advantages. When a prosthesis is chosen, however, factors related to the patient and the surgeon should be taken into consideration as well as its function. Thus, the prosthesis chosen will differ between patients and surgeons. Various total hip replacement prostheses are currently available and it is impossible to deal with all of them in this article. In addition, there is not necessarily a consensus among surgeons about the indications for each prosthesis. Therefore, the following article will mainly explain the most common views in a systematic manner.

The Durability of Total Hip Prostheses

How long can the current total hip arthroplasty components last? This question is not easy to answer. In a multicenter follow-up study of Charnley’s total hip arthroplasty involving about 5,000 patients, 83% of the primary implants were effective for at least 20 years.1) If this is defined as the 20-year survival rate for hip prostheses, then the recent 10-year survival rate is 97–98%, indicating that total hip arthroplasty has become extremely successful.2,3) Consequently, prostheses that are selected for clinical use should have an expected life exceeding this period and those which are less durable should not be used.

Types of Hip Prostheses

A total hip prosthesis usually consists of two components, a socket that is fixed to the acetabulum and a stem that is inserted into the femur. In addition, there is another type called a monopolar or bipolar prosthesis comprising a single component or a femoral head alone with no acetabular component.

The method of fixation can be classified as follows; 1) cemented, 2) cementless, and 3) hybrid. In the third category, each of the two components is fixed to the bones in different ways. Further classifications based on the materials and surface of each component are possible.

With respect to the type of articular surface, the combination of an ultra-high molecular weight polyethylene socket and a metal or ceramic femoral head is the most common. Metal-metal and ceramic-ceramic combinations have also been developed recently.

To determine the indications for each type of prosthesis, the following factors should be taken into consideration.

With the monopolar prosthesis, in which the
femoral stem and head are united, both components move as one. The prosthetic femoral head articulates with the patient’s acetabulum to reconstruct a functional joint. This type of joint replacement was developed about 50 years ago. Consequently, it has been tested for about 50 years in clinical use. It is structurally simple and produces little wear debris, a cause of osteolysis. Despite these advantages, there is a possibility of the acetabular cartilage and bone being worn away by mechanical friction, leading to migration of the prosthetic head. The majority view seems to be that use of this type of prosthesis is currently limited to fractures of the femoral neck in relatively inactive elderly patients. Low cost may be another reason to choose this type, because it is less expensive than bipolar prostheses as described below.

The bipolar prostheses are discussed next (Fig. 2). The first bipolar prosthesis was developed about 25 years ago in order to overcome the drawbacks of the monopolar prosthesis. The bipolar prosthesis, which has two functional joints, is also called a dual-bearing type. In other words, the prosthetic femoral head consists of two parts, the outer surface of the outer part articulates with the patient’s acetabulum, while the inner surface articulates with the core of the prosthetic femoral head via bearings that lie between them.

Because the motion allowed between the acetabulum and the outer surface of a bipolar prosthesis is smaller compared with that between the acetabulum and a monopolar prosthesis, it was expected that migration of the prosthetic femoral head would also be suppressed. In fact, hemiarthroplasty with a bipolar hip prosthesis for fractures of the neck of the femur and necrosis of the femoral head was found to be successful if the acetabular cartilage had been preserved. Consequently, bipolar hip prostheses are used widely at present. In patients with osteoarthrosis of the hip, bipolar hip arthroplasty was also used instead of standard total hip arthroplasty. The outcome was initially excellent. At 10 years or more after implantation, however, migration of the femoral head showed a high incidence. Moreover, osteolysis due to wear debris from the articular surface has been recognized. Bipolar hemiarthroplasty was performed for relatively young patients at first because revision was thought to be easy. However, the frequent occurrence of migration of the femoral head made this procedure less beneficial than total hip arthroplasty with regard to preservation of the acetabular bone. This seems to be the current consensus.

The main subject of this article is total hip arthroplasty, and the indications for this procedure will be discussed under various categories.

There are two major techniques of fixation, which are cemented (Fig. 3) and cementless (Fig. 4). The method that should be chosen is one of the most controversial issues even among experts.

Cemented fixation has various advantages. In general, rigid fixation can be obtained immediately after the operation, this technique can be applied despite variations in the
morphology and properties of the bone, and the interface produced by cemented fixation is resistant to the penetration of wear debris. However, several drawbacks have been also recognised. The outcome varies considerably depending on whether or not the intraoperative cementing process is successful, rarefaction of the adjacent bone is often accelerated if the prosthesis becomes loosened, the cement may be difficult to remove at revision hip arthroplasty, and fixation of the socket is inferior to that of the stem.

The advantages of cementless fixation include extremely rigid fixation if bone growth into the pores of the surface coating occurs, relatively good preservation of bone mass even if loosening occurs, and the fact that revision arthroplasty can be performed without removing cement. Drawbacks include possible contraindication when the bone is inappropriate, occasional poor fixation due to subsidence of the implant or for other reasons when the initial fixation is insufficient, more common occurrence of osteolysis due to wear debris than after cemented fixation, the potential extreme difficulty of extracting an implant that is firmly fixed, and the possible persistence of femoral pain. Regardless of the method of fixation, an implanted prosthesis causes mechanical stress on the bone to become nonphysiological. Consequently, the bone around the implant may undergo atrophy, rarefaction, or hypertrophy during the long postoperative course.

The selection of a method for fixation should not only be based on durability and functional advantages, but also on the countermeasures available for coping with complications or revision in the future. In other words, the surgical procedure to be used for revision, the extent of invasion, and the method of handling bone defects should all be taken into consideration when a technique for fixation is selected.

The following section discusses prostheses using a classification based on the type of articular surface. Because the methods of fixation have gradually been improved, some
Researchers now consider that the longevity of artificial joints depends on the rapidity and severity of wear.\(^6\) Even if excellent fixation is obtained after total hip arthroplasty, the bone around the implant begins to undergo osteolysis from 10 years or more after the operation and this may result in loosening. It has been clarified that the major cause of osteolysis is wear debris from the polyethylene covering the articular surface.

Several attempts have been made to prevent this osteolysis, including improvement of the articular surface of the femoral head by a better polishing technique, the use of an alumina or zirconia ceramic head in place of the conventional metal head, improvement of the resistance to frictional wear by using polyethylene with a higher molecular weight and intermolecular crosslinking, and the use of a ceramic or metal socket in place of polyethylene to produce a ceramic-ceramic (Fig. 4B) or metal-metal combination prosthesis, respectively. The long-term outcome is already known for some of these methods.

With a ceramic-ceramic prosthesis, although there are few wear debris, the long-term outcome is no better than that for the conventional prosthesis.\(^7\) This suggests that the material used in place of the conventional polyethylene to reduce wear may alter the physical properties of the implant such as the friction coefficient and the rigidity of fixation. Thus, attempts at improvement cannot accomplish their goal unless the reconstructed joint is well-balanced. Recent research has indicated that remarkable progress may be achieved regarding this problem in the near future.

**Patient Factors**

When total hip arthroplasty is indicated, a prosthesis is selected by taking the patient’s age and underlying disease into consideration because the properties and morphology of the host bone will depend on these factors.

With regard to selection based on the patient’s age, usually cementless fixation is indicated for relatively young patients and cemented fixation for elderly patients. Because younger patients are more active and often require revision in the future, cementless fixation, which allows rigid fixation with the possibility of preserving the bone mass, is chosen. This policy is not absolute, however, and the possibility of osteolysis and difficulty of removing the implant at revision should be considered.

When the patient has osteoporosis, e.g., patients with rheumatoid arthritis and elderly patients, cemented fixation is usually considered more appropriate because the cementless method often fails to achieve rigid initial fixation. When the acetabulum and the femur are small and deformed as in patients with congenital acetabular dysplasia, reconstruction by a cementless technique is sometimes difficult and cemented fixation may be better. The selection procedure described above is generally applicable. However, some surgeons have employed different selection criteria based on various modifications invented for particular purposes.

**Factors Related to the Surgeon**

If arthroplasty is performed with a new prosthesis that the surgeon is using for the first time, it is difficult to accomplish the operation perfectly, no matter how skilful the surgeon may be. Even though different prostheses are available for different indications, if there are too many choices, the surgeon’s experience with a particular prosthesis may be inadequate. It is often difficult to fully understand the advantages and drawbacks of a certain type of prosthesis without sufficient clinical experience.

For example, cemented fixation requires considerable skill to achieve an excellent result. With the cementless technique, the rigidity of fixation depends on the size of the prosthesis selected and experience in using the...
surgical instruments. Consequently, using too many types of prostheses for different conditions is not a good method of maintaining the outcome of arthroplasty at a high standard. It seems to be more appropriate to choose one prosthesis with which the best long-term results are achieved as the main type and also provide one or two additional options.

Conclusion

The earliest clinical success with total hip arthroplasty was confirmed more than 30 years ago and the value of total hip arthroplasty as one of the most useful therapeutic procedures in the orthopedic field has been established. With respect to the long-term outcome, a 10-year prosthetic survival rate of nearly 100% has been reported occasionally. Not only improvement of instruments, but also attempts to maintain a certain standard for individual operations based on the training of surgeons needs to be considered.

In conclusion, I would like to emphasize the necessity of considering the prolonged postoperative course over 30 years or more and the need for revision arthroplasty, particularly when total hip arthroplasty is indicated for young patients.

REFERENCES