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## Total Joint Replacement ( 1-Jan-1985 )

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Total joint replacement is presently used in the dog for hip replacement.(1)It is used as an experimental procedure in other joints in other species.(13,15) This chapter explores total joint replacements as they relate to the clinical problems that require their use. Many of the early studies in total joint replacement were carried out in humans, and many of the experimental procedures that have been used in animals were designed to solve the problems that occurred in people. More recently studies have been designed using primarily animal models.(11,13) Clinical total hip replacement in the dog has evolved from the use of the dog as a model for a device that could be applied to humans, into a form of treatment for the animal with debilitating joint disease.

### HISTORY

The recent history of total hip replacement in humans started with the advent of the use of polymethylmethacrylate (PMMA) to anchor the device by Charnley in the late 1950s. Charnley's first total hip replacement, of which Teflon was one component, had severe wear problems. These problems were solved by manufacturing the acetabular cup of high-density polyethylene (ultra high molecular weight polyethylene). This same material is used in many devices today(15)

The early designs that were popular in the 1960s consisted of metal cups and metal heads with metal stems. They had problems of high wear and loosening. Both the Ring and McKee-Farrar prostheses fell into this group. The Ring prosthesis utilized a design incorporating a screw for fixation of the acetabular component with a long straight femoral stem. Fixation with cement (PMMA) was optional. The gradual shift to the metal-polyethylene wear interface seemed to do much to solve the problem of wear, but loosening has continued to be a significant complication of long-term use in humans.(14)



FIG. 44-1 (A) This total joint replacement was modeled after a human prosthesis and was used in both clinical and research environments. The device used a separate polyethylene head, which rotated on the trunnion bearing of the stem. The device was used with PMMA, as shown in radiograph (B), in which an old femoral head and neck fracture was treated by total joint replacement (C, D). This animal was followed for 22 months before being lost to follow-up. Two additional animals were operated upon in that same time span (1969-1971).

There has been much less experience with canine total joint replacement.(2,8,10,12) Although endoprostheses for hip replacement had been used previously with relatively poor results, the first total joint replacement for use in the dog was developed by Gorman.(4) This total hip joint, which consisted of an interlocked ball and socket joint, was attached to the acetabulum with three screws and into the medullary cavity of the femur with a simple long stem following manual reduction. This device was used extensively but showed certain shortcomings, which were related to loosening of both the

stem and the acetabulum. Lameness was associated with this loosening, and revisions were not successful. In contrast to the development of the total hip replacement in humans, development in the dog ceased for about 10 years until the dog was being looked at as a model for the study of total hip replacement in humans. At this time (late 1960s-early 1970s), a number of dog studies were instituted using old designs incorporating the use of PMMA for cementing the device into the bone.<sup>2</sup> New designs were also presented that made use of the ability of the PMMA to stabilize the prosthesis (Fig. 44-1)(5,12)

Problems with loosening, even with the use of PMMA, led to experimentation with biologic ingrowth systems to provide implant stabilization (Fig. 44-2).(12,16) Porous materials were used to allow the ingrowth of bone or fibrous material into the prosthesis in an attempt to eliminate loosening. As time has passed some of the problems of loosening have been solved by the use of special techniques for inserting cemented prostheses as well by the development of various biologic ingrowth devices for use in humans. The complete answer has not been found, and the optimal design for an implant using PMMA or biologic ingrowth has not yet been discovered.



FIG. 44-2 The same prosthesis as seen in Figure 44-1 was coated with a porous Wintered metal coating (A) and used without cement to study biologic ingrowth. These studies showed excellent stabilization and clinical results, as evident in the 1-year postoperative radiograph of an experimental animal (B). Mechanical tests showed a high-strength bony interface (C). Histologic studies showed bone ingrowth into the porous material when used as a weight-bearing device (D). The black area on the photomicrograph represents the Wintered metal that was cut and included in the section. A transverse microradiograph (E) demonstrates the bony ingrowth into this femoral stem. Problems with this early work were related to the poor choice of metal that induced corrosion of the Wintered coating.

In humans the loosening of the cup and stem of the total hip joint prosthesis still represents a significant problem, especially in the younger, more active patient. The total hip is the most widely used and most successful total joint prosthesis in humans. All other total joint prostheses have a less optimal performance record.(14)

In the dog the clinical documentation of total hip prosthesis has been very limited. Only one type of hip joint has been used in most published clinical studies,(7,8,10) and currently only one device is manufactured for use in the dog. This device is the Richards II canine total hip prosthesis. The first model for this prosthesis was a human joint that was sized for large dogs, but it limited the range of hip motion (see Fig. 44-1). This early device was planned for experimentation only, but it was used in a small series of dogs,(5,12) the results of which were never published. The newer Richards II model was sized specifically for the dog and the design was changed. This prosthesis is made in several sizes and has been reported in the veterinary literature since the late 1970s (Fig. 44-3)(7,8,10)



FIG. 44-3 A 14-month old rottweiler with hip dysplasia (A) was treated by total joint replacement (B). The dog is seen again in this 164-week follow-up radiograph (C). Note the increased bone stock around the stem of the prosthesis, indicating some interaction between the implant and bone. The bone remodeling is thought to be related to weightbearing stresses; at times it causes hypertrophy, at other times, resorption. (Courtesy of M. L. Olmstead, Ohio State University)

Recently a group from Ohio State University reported on their clinical experience with the Richards II total hip prosthesis. (10) This report, although the largest yet, did not address the problems of total joint replacement in terms of longevity. Less than eleven dogs were actively followed for 5 years; 67.4% of the dogs were still under review at the time of publication submission. Although 91.2% of the dogs with total joint replacement had a satisfactory result at their latest evaluation, this number may be misleading when describing the total population of 221 total joint replacements reported in the article, since 11.7% of the dogs were lost to followup, 7.2% of the dogs had their prosthesis removed, and 13.5% of the dogs were already dead for whatever reasons. This would mean that since 32.4% of the population was removed, 91.2% of the remaining 67% of the dogs had a satisfactory result. This demonstrates that we really do not know what the long-range (5 years) outcome of total hip replacement is in the dog. Certainly in humans the longterm problems are those of implant loosening (> 30%), infection (1%-5%), and implant failure (<1%).(14) The experience in the dog may parallel that in humans. Although the species difference may play a role, it should be remembered that the device was intended to relieve pain and increase mobility in elderly human patients. In the dog the device is used for the same reasons, but in a younger population that is generally more athletic and will be expected to stress the device at a higher level. Since the life spans of the two species are

so different, the dog will not require the same degree of longevity as humans. However, the devices used in humans do wear and must on occasion be replaced. There are no data available on how long the device will last in an athletic dog.

Total joint replacements have not been limited to application in dogs, or for that matter to total replacement of the hip (Fig. 44-4). However, most of the other total joint replacements used in animals have been experimentation for application in humans (Fig. 44-5).<sup>(13)</sup> Many of the research projects that are done in animals result in successful applications, but the clinical need to replace other joints in animals may be limited.

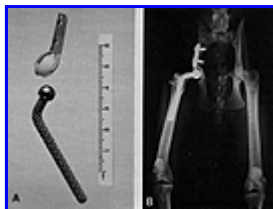


FIG. 44-4 This hip prosthesis (A) was designed for research use in the cat as an inexpensive total joint prosthesis. The prosthesis joint was stabilized with biologic ingrowth. The interface was created by rolled knerling. The acetabulum was a snap-together device that allowed accurate positioning via its side plate. The device was implanted with two screws that were used for temporary fixation to allow biologic ingrowth to occur. (B) Radiograph at 5-year follow-up of a cat with one of these prostheses. The animal can climb trees and seems fully functional.

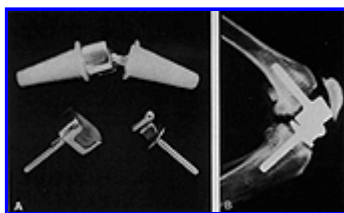


FIG. 44-5 (A) This four-part device was used as a prototype for total finger joint replacement in humans. It allows biologic ingrowth to occur for joint stabilization. A 24week postoperative radiograph (B) was taken during an experiment in which this device was implanted in the knee of a cat. The joint worked well in the cat knee as a total joint replacement.

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## INDICATIONS

The present experience with the use of total joint replacement in animals as a clinical tool has not provided the broad indications that are used in humans. The dogs that seem to do best are those animals that are neurologically competent and in general good health. These are animals that have degenerative joint disease of one or only a few joints. Painful degenerative arthritis secondary to hip dysplasia is the most common indication, animals with failed femoral head and neck excisions are also reasonable candidates for the procedure.<sup>(3)</sup> Any other painful condition of the hip that preserves the muscular ability of the animal and is not related to oncologic problems is an indication for possible total joint replacement. There are two basic concerns regarding indications for total hip replacement. First, the procedure has an excellent early result if done properly; thus, the clinician is enthusiastic about it. Second, complications, however uncommon, can be devastating to an animal that was treated with an elective procedure. Approximately 20% of the animals in the Ohio series had a serious complication.<sup>(10)</sup> Slightly more than half of these animals had a satisfactory outcome after further surgery or further conservative therapy. Therefore one might expect that approximately 10% of the dogs chosen for this procedure will have a serious complication that will not resolve into a satisfactory result regardless of the number of revision surgeries. This interpretation of the data that are available is meant to help ensure that the benefit-risk ratio is properly assessed before the decision for surgery is made.

The dogs that are the best candidates for the procedure are those animals that are larger than can be expected to have a good result with an excision arthroplasty but smaller than the sloppy-gaited giant breed dogs that seem not to benefit by total hip replacement. Thus, the best results can be expected in dogs in the 18kg to 35-kg range, which fortunately includes those breeds affected most profoundly by hip dysplasia.

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## SURGICAL PROCEDURE

The implantation of the total hip joint in the dog has been performed in a variety of ways. The cranial approach has been used most widely and has been described by Olmstead and co-workers.<sup>(9)</sup> In this procedure the femoral head is excised using the prosthesis as an overlay to determine the proper length and angle for the osteotomy of the femoral neck. The acetabulum is then reamed using the appropriate sized reamer, and the anchoring holes for keying in the PMMA are made using a twist drill or curette. The shaft of the femur is opened through the cancellous bone visualized at the level of the femoral head osteotomy in the neck of the femur. The shaft is reamed with the appropriate sized shaft reamer and the marrow cavity is flushed with saline to remove any excess debris, cleansing the cavity so that the PMMA can interdigitate properly into the bone. PMMA is really a Outing agent and does not have any adhesive properties as used in this mode. It increases the contact area between

the prosthesis and the bone. The great increase in stabilization that occurs is caused by this Outing effect. Therefore the surfaces that are to be mated must be clean and free of excess fluid.

Following preparation of the bed in both the acetabulum and marrow cavity of the femur, a trial fitting of the prosthesis is in order. This will allow the surgeon to make adjustments before the PMMA is used to fix the prosthesis. If the fit is satisfactory, the acetabular component is cemented into position using a guide to establish the proper angle of placement. Following this the shaft portion of the prosthesis is again inserted as a trial prosthesis and a reduction is accomplished. If all is well the femoral stem is removed and the PMMA is introduced into the medullary cavity followed by the femoral stem prosthesis. The introduction of the PMMA into the femoral marrow cavity may be somewhat difficult because of the trapped air within the cavity. It is very important that the PMMA be in contact with the femoral stem along its entire length. It should also go below the bottom of the stem if loosening complications are to be avoided. In humans the bottom of the marrow cavity may be sealed with a small plug of PMMA prior to introduction of the rest of the PMMA, and the cavity is filled from the bottom to the top using a large syringe and a long tube containing low-viscosity PMMA before it reaches the doughy stage. This technique has been discussed briefly in the veterinary literatures. The prosthesis is then inserted immediately to try to force the PMMA into the surrounding bone under pressured. It is felt that this method will help prevent the long-term loosening problem that occurs in humans. In the dog the PMMA has usually been applied in the dough stage by pushing it into the marrow cavity with finger pressure. Following positioning of the femoral stem, the new joint should be flushed with saline to remove any chips of PMMA that may be within the acetabular cup. The presence of debris will significantly decrease the longevity of the implant and quality of the clinical result. The joint is then reduced and the wound is closed. The procedure outlined here is critical to the outcome of the case. Techniques of implantation are not learned by reading technical papers but by active participation with those that have experience.

Postoperative care consists of limiting the degree of exercise by cage rest for the first week followed by continued restriction at home. The animal should not be allowed to run free for the first month following surgery. This is to allow the soft tissues to heal, since the prosthesis is as strong as it ever will be only minutes after the PMMA polymerizes.

The use of prophylactic antibiotics is suggested. Since the PMMA cures with a high heat phase, antibiotics have been used to protect these injured tissues for a week or two. This extended use of antibiotics goes beyond the usual description of prophylaxis but has been seen to be beneficial in the human series. Antibiotic-impregnated PMMA has also been used to protect the patient from infection. Gentamicin is used most often in humans and cephalothin powder mixed with the PMMA has been suggested in the veterinary literature.(10)

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## COMPLICATIONS

The most common complications associated with total hip replacement in the dog are dislocation, infection, loosening of the acetabular component, fracture of the femur, and neuropraxia.(10)

Although all of these complications may be disastrous, infection represents the one most difficult to treat. If the implant becomes infected, it must be removed. The PMMA must also be removed, and its removal is most difficult. Anyone implanting a total joint device using PMMA for anchorage, must also have the tools to be able to remove the device. Any PMMA left behind will act as a nidus for further infection. The tool used most commonly for this purpose in humans is named the Midis Rex, which tells something about the difficulty of PMMA removal.(14)

Dislocation is usually a result of improper technique in positioning of the acetabular cup or of improper length-tension relationship of the femoral stem and acetabular cup. On occasion the complication can be rectified by closed reduction, but more often surgical revision must be carried out. Loosening of the acetabular cup may be caused by improper anchoring of the cup initially. Sometimes loosening may be a sign of infection. It is extremely important to do aerobic and anaerobic cultures of each and every complication that requires reoperation.

Fracture of the femur can occur as an operative complication, a postoperative complication with the implant in place, or as a postoperative complication after the removal of the implant for whatever reason. The fractures are dealt with in a normal fashion except that the marrow cavity may not be available to the surgeon if the prosthesis is in place. Infection superimposed on the fracture can be grave indeed.

The neuropraxias reported usually resolve themselves with time but are the result of technical errors associated with the implantation of the device.

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