Clinical Evaluation of Geometric Knee Arthroplasty

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Geometric knee arthroplasties were done in seventy patients or eighty knees; sixty-two knees with osteoarthritis, fifteen knees with rheumatiod arthritis, the rest were gouty arthritis, ankylosing spondylitis and traumatic arthritis. Clinical study of these patients were made from five months to five years after the operation.

Using the criteria of evaluation as suggested by Hunter, seventy four knees or 92% were rated as good, six knees or 8% were rated as bad. The results were similar to that reported by Coventry at Mayo Clinic. The subjective results were similar to the objective results. Relief of pain was the most gratifying result. There was no serious complications.

From this study it is concluded that geometric knee arthroplasty in properly selected patients, is a worthwhile operation to relieve pain and improve function in arthritic patients. A further study should be made on these patients when sufficient time has elapsed to determine the end results.

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Arthroplasty of the knee has long been a challenge to the orthopaedic surgeon. Many methods and techniques have been tried during the past 100 years, which in general have been unsatisfactory.

Credit for the first arthroplasty belongs to John Rhea Barton, who in 1826 performed an osteotomy adjacent to an ankylosed temporomandibular joint in an attempt to restore motion by utilizing a pseudarthrosis.

The use of interposing membranes or materials such as joint capsule, muscle, chromised pig bladder, fascia lata, cellophane and nylon were tried by various surgeons during the year 1863-1953. A major problem in tissue or membrane arthroplasty is that it cannot withstand the pressure in the weight-bearing joint, and some materials produce irritative fibrosis and were finally abandoned.

Because of the poor success in using various soft tissue, Chevensky first employed a metallic implant in an animal experimentation in 1900. He utilized magnesium plates with the most promising results. Since then metallic implant arthroplasty has grown in popularity.

The distal femoral replacement arthroplasty by a vitallium mold was tried by Campbell in 1940[1] and Smith-Petersen[2] in 1942 with poor results. In 1953,

the mold was modified by Jones and Smith-Petersen to include an intramedullary stem. The results of these procedures at Massachusetts General Hospital, reported by Jones in 1967,[3] revealed 51% to be successful. This type of prosthesis has been subsequently investigated by Aufranc.

During the 1950s and the 1960s the use of hinge-joint prostheses had been reported by several surgeons. The results at that time was so far unacceptable because of erosion of the stainless steel implant, loosening of the implant, high incidence of deep infection and massive skin sloughing. The motion of knee joint is complicated, it is not a simple hinge joint. During motion, there is some degrees of rotation with sliding or gliding among the tibio-femoral joint. Therefore any attempts to replace the knee with a simple hinge joint have been generally unsuccessful. Currently GUEPAR hinge knee prosthesis has been introduced, but it is reserved for either very old patients or grossly dislocated knees.[4]

Metal tibial plateau replacement prostheses were used in 1950 by Mc Keever,[5] in 1953 by Townley,[6] and in 1966 by Mac Intosh.[7] Mac Intosh introduced his first prosthesis in 1954 which was made of acrylic and mainly to correct the varus or valgus deformity that characterized many cases of osteo-arthritis of the knee. The use of these prostheses have been discontinued because of unsatisfactory results.

The present era of total knee arthroplasty commenced in the early 1970's, when the Gunston polycentric prostheses were introduced by Peterson and Bryan[8-10] in 1971 and the Geometric prosthesis was introduced by Coventry[11,12] at the Mayo Clinic shortly after. These 2 types of prostheses are an attempt to simulate the normal mechanics of knee joint while providing stability and motion of at least 90 degrees, and also allowing some degrees of rotation of the femoral and tibial components. The cruciate and collateral ligaments are preserved in which minimal amount of bone is removed during insertion of these types of prosthesis.

The first geometric total knee prostheses were inserted at the Mayo Clinic on April 27, 1971. Since then the geometric design has been changed during the ensuing years to allow better fixation of the tibial unit, and was named Mark I, Mark II, Mark III and Mark IV respectively.

DESIGN OF GEOMETRIC PROSTHESIS

The Geometric (Mark III) total knee prosthesis (Figure 1) has a bicondylar vitallium femoral component in which the two femoral weight bearing surfaces are joined by an anterior crossbar. The matching tibial unit is a single interlocked piece of high-density polyethylene, designing to replace both tibial plateaus. Each unit is affixed into the bone with acrylic cement. This prosthesis is intrinsically stable in both the antero-posterior and lateral planes.

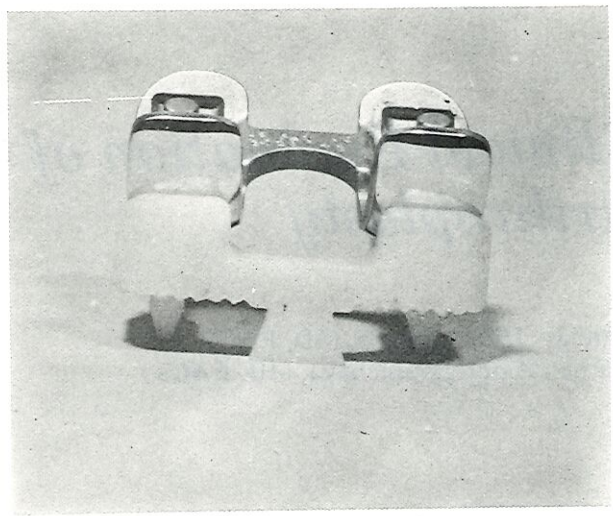

Fig. 1 The geometric total knee (Mark III) prosthesis.

OPERATIVE TECHNIQUE

The approach must provide an adequate exposure for the preparation of bone beds for the prosthesis, for synovectomy and for any reshaping of femoral condyles.

Through a median parapatellar incision or midline incision the vastus medialis is detached from the upper medial border of the patella, and the quadriceps tendon is split along the line of the fibers. The incision is carried to the patellar tendon insertion, allowing the patella to be completely everted thus exposing the whole joint at the front.

Synovectomy is done only in the case of rheumatoid arthritis. The dissection starts at suprapatellar pouch using sharp and blunt dissections. The osteophytic margins are removed. Patellectomy is avoided, if possible, because return to active function is slower and more difficult after patellectomy.

The detail of the technique of prosthetic insertion has been described by the manufacturer and in various literatures. It requires personal experience in adjusting the proper position of the prosthesis as well as the optimal tension of the soft tissues at any point in the arch of motion between full extension and 90 degrees of flexion. The valgus on varus deformity of the knee is corrected by removing of bone from medial or lateral plateaus or partly from femoral condyles. Care is required in order not to fracture through the intercondylar area where the cruciate ligaments attach.

Only the small size of prosthesis is recommended for the use in average Thai people.

POSTOPERATIVE MANAGEMENT

The knee is kept in full extension in Jones compression bandage and posterior plaster splint for four or five days. A hemovac is inserted in the operating room and removed after 48 hours. Antigravity active range of motion of the knee begins immediately following the discontinuation of the compressive dressing. During the first week after the removal of the compression dressing, a post-operative knee immobilizer is used at all time, except during the periods of therapy. Once active control of the knee is regained, the immibilizer is used only at night. The knee motion is commenced with an objective of 90 degrees flexion within two weeks. If this range is not obtained during this time, gental flexion of the knee under sedation or general anesthesia may be required.

Manipulation can be repeated in three to four weeks. Excessive force used in manipulation must be avoided because this will compress the prosthesis into the tibial bed. Occasionally corticosteriod is injected into the joint during manipulation to facilitate the rehabilitation program.

Range of knee motion exercise should be done four times per day both by physical therapist and attending physician in order to avoid manipulation. We have found that application of an ice pack around the knee along with giving analgesics prior to and after the range of motion exercise is very beneficial.

Quadriceps exercises are started as early as possible. At first, straight leg raising and quadriceps drilling is done. Later on, resistive exercises are encouraged. Once 90 degrees of motion and active control of the knee is achieved, the patients are allowed partial weight-bearing with crutches or walker ambulation. They should maintain partial weight-bearing until three months post surgery.

CLINICAL MATERIALS

From June 1974 to January 1979, geometric knee arthroplasties (Mark III) have been performed by the authors at Siriraj Hospital on 70 patients or 80 knees.

The maximum follow-up of these patients was five years, and the minimum was five months.

One patient who had bilateral joint replacement died from myocardial infarction one year after the operation. All the patients were personally evaluated by the anthors at the final assesment. Ten of the patients had bilateral procedures.

Age The age of the patients at the time of surgery ranged from 19 to 86 years, with median age of 57 years

Sex The sex distribution was 55 women and 15 men

Career They were mainly light workers, 40 patients were government officers, 12 patients were running business. The rest were house-wife and retired people.

INDICATION FOR OPERATION

1. Osteo-arthritis 58 patients, 62 knees
2. Rheumatoid arthritis 9 patients, 15 knees
3. Gouty arthritis 1 patient, 1 knee, this case was incorrectly diagnosed as osteo-arthritis pre-operatively.
4. Ankylosing spondylitis 1 patient, 1 knee
5. Traumatic arthritis 1 patient, 1 knee

All of the patients had adequate medical treatment including physical therapy prior to surgery. They were in the late stage of disease, which was beyond the treatment by simple synovectomy, joint debridement, or osteotomy. The main criterion for patient selection is severely disabling pain in older individual due to bicompartmental involvement from either rheumatoid or degenerative arthritis. The three firmest contraindications are recent infection, lack of muscular control of the knee particularly that involving the quadriceps, and neuropathic or Charcot's joint.

SURGICAL PROCEDURE PRIOR TO ARTHROPLASTY

Five patients had undergone surgery prior to knee arthroplasty. Two patients had synovectomy for rheumatoid arthritis, another two patients had proximal tibial osteotomy to correct varus deformity due to osteo-arthritis. There was one patient had patellectomy several years prior to knee arthroplasty.

METHOD OF EVALUATION

The evaluation of post-operative results following knee arthroplasty is extremely difficult due to :

1. Progression of the disease process or recurrence of the disease activity.
2. Most of the patients have multiple joints involvement.
3. Varying severity of the disease or involvement of the joint pre-operatively.
4. Inadequate examination or evaluation of the knee pre-operatively.

On reviewing the literatures, there is no standard rating system for evaluation of the knee arthroplasty. Most authors have reported their results as "Improved" or "Unimproved", "Satisfactory" or "Unsatisfactory", and others have listed as "Good-Fair-Poor", with different definitions of each classification. The criteria of evaluation are identical, which depend on pain, range of motion, stability, and walking capacity.

The point system recently devised by Marvin S. Weinfeld at Boston is an excellent and precise way of evaluation; but it is impractical to use on these patients. For example, one's rating as an excellent re-

sult, patient has to be completely pain-free and walk without support at all, which is impossible for such a disabling disease, we have tried to use this system and the results were very confusing.

We find that the method which suggested by G.A. Hunter[13] of Toronto is practical. He classified the result as "Good" or "Bad". For the result to be "Good", there have to be :

1. Relief of pain
2. Correction of lateral deformity; clinical measurement of 10 degrees valgus, 5 degrees varus, being acceptable
3. Has minimal range of motion of 60 degrees.
4. Improvement of function and gait compared with pre-operative level.
5. Stability to the patient and stable to the examiner when assessing quadriceps power, medial and lateral instability, and antero-posterior cruciate instability.

In this evaluation, we also asked the patients to freely give their comments about the result of the operations.

CASES ILLUSTRATION

CASE 1 This patient was a 44 year-old female, house-keeper. She was obese and had been doing a lot of walking every day. She had been suffering from knee pain with progressive deformity especially on the left side for over 10 years. At the time of her admission she used cane for ambulation and could walk only a short distance. The left knee was markedly bowed on standing with severe degree of lateral instability, no flexion contracture, having full range of motion.

Fig. 2 Photograph showed marked varus deformity of the left knee on weight bearing before the operation. (Case 1).

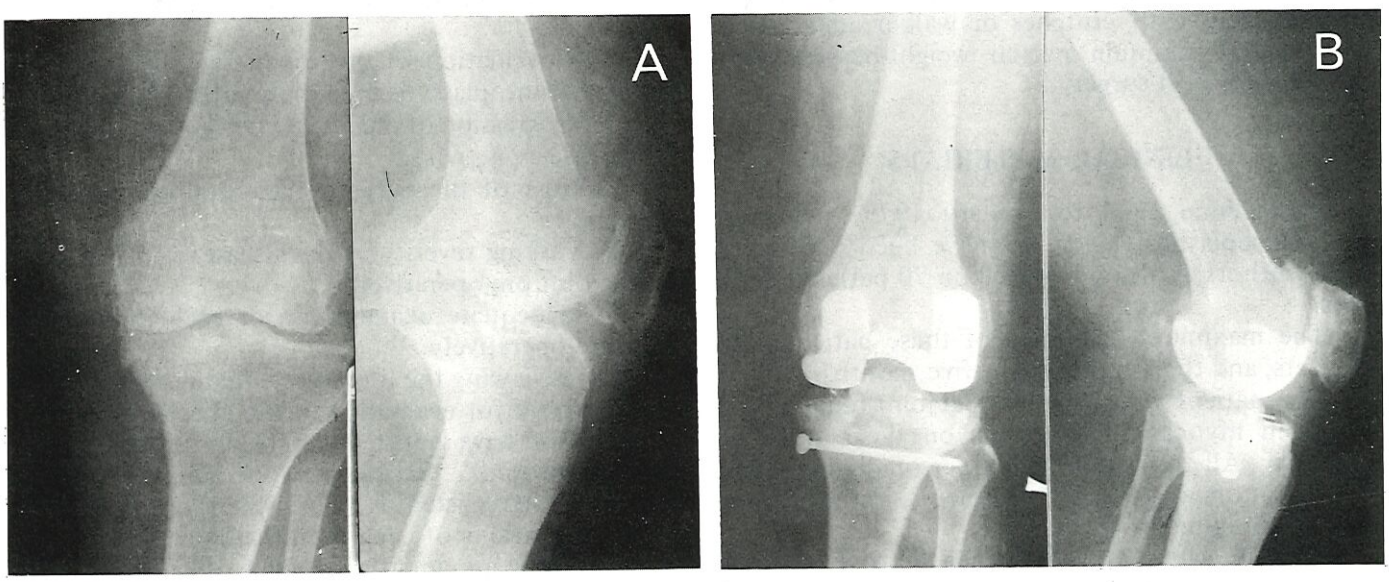

Fig. 3 A. Preoperative radiograph showed severe destruction of the knee joint due to osteoarthritis. The medial tibial plateau was depressed causing varus deformity on standing. B. Radiograph after insertion of geometric knee showing the deformity was corrected. The medial tibial condyle was vertically fractured during the operation and a screw was used to stabilize the fracture.(Case 1).

Geometric knee arthroplasty was performed on the left side. She had a good result at one year follow-up, when the deformity had been corrected, and the range of motion was 0° to 110°. The lateral instability still persisted, but in lesser degree. The pre-operative and post-operative pictures were shown in Figures 2,3 and 4. This patient was graded as "good" result.

CASE 2 This was a 51 year-old female with a long standing history of rheumatoid poly-arthritis. Over the two years prior to her admission, she developed an increasing pain in the right knee with decreasing ability in ambulation. She regressed from walking to a wheel chair, and the walking was limited only around the house. On admission, both knees were swollen with boggy synovium and valgus deformity of 15°, flexion contracture of 20°. The patient was hardly able to bear weight because of pain. There was creptitus on patellar gliding with lateral instability. The range of motion was 20° to 140°. Geometric arthroplasty was performed on the right knee, the patient made a very uneventful post-operative recovery, but she had a slow post-operative rehabilitation due to the multiple joints involvement. Now she has mild pain on the operated knee and the range of motion was 0° to 100° with mild laxity on varus stress test. She still cannot walk due to the pain on opposite knee. The pre-operative and post-operative films were shown on Figure 5. This patient was graded as "good" result.

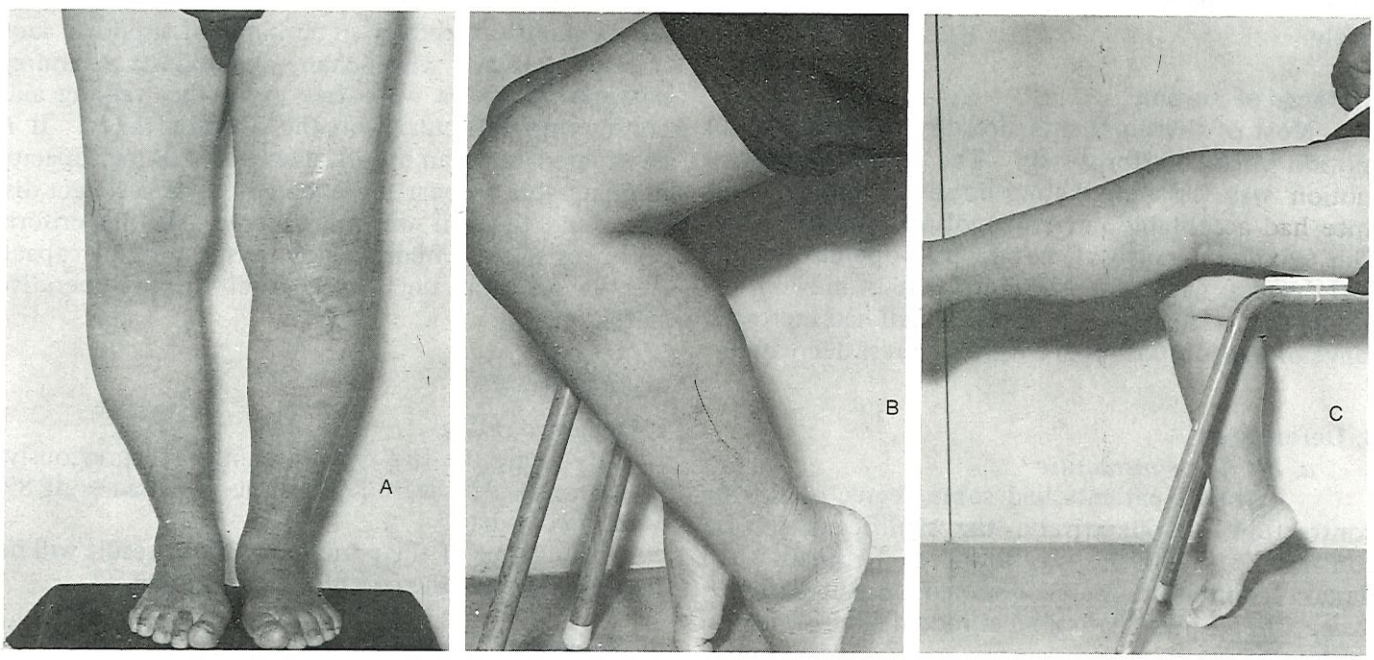

Fig. 4 Photograph of the knee after the operation showing the knee to be straight (a), having good flexion (b) and extension (c). (Case 1).

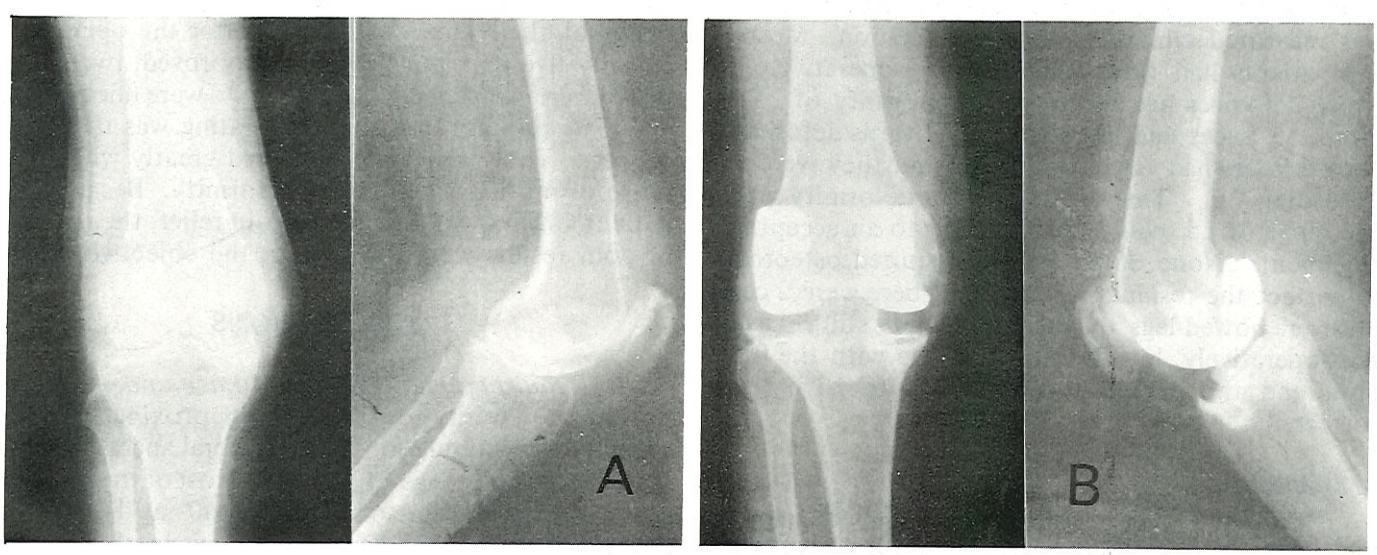

Fig. 5 AP and lateral radiographs of the knee before the operation showing joint destruction from rheumatoid arthritis (a). Postoperative radiographs showed the geometric prosthesis in place (b). (Case 2)

RESULTS

A. Criteria for Evaluation

1. Pain

Pain was the main subjective factor, and relief of pain was a primary indication for the operation. We noted pain at rest and its relation to weight-bearing; and graded the intensity as mild, moderate or severe. Pre-operatively, there was 52 knees with severe pain and 28 knees with moderate pain. Post-operatively, 57 knees had no pain both at rest and on walking, 20 knees had mild pain, and 3 knees were unchanged. In 20 knees that still had mild pain post-operatively the amount of pain was significantly less than pre-operatively.

2. Range of motion

Most of these patients already had full range of motion prior to arthroplasty. The effect on range of motion was less remarkable, however, almost every knee had acceptable range of motion or good result. The maximum range of motion post-operatively was 120 degrees, while the minimum range of motion was 45 degrees. There were 4 knees which had increased range of motion post-operatively, the rest decreased.

3. Deformities

a. Flexion contracture

Most of patients had some degree of flexion contracture pre-operatively, the significant flexion contracture of 30°-45° was found in 17 knees. All flexion contracture were corrected post-operatively, except for 8 knees that still had mild degree of flexion contracture.

b. Varus and valgus deformity

We consider the valgus deformity of 10° and varus deformity of 5° as an acceptable alignment. This was measured clinically in supine position. Most of the patients had varus deformity pre-operatively, of which 19 knees had severe varus deformity of 25° or more, 55 knees had less than 25° of varus deformity. Only 6 knees had valgus deformity, but they were not exceeding 25°. The valgus or vaus deformitywithin the range of 25° could be corrected to an acceptable alignment. None of the patient required osteotomy to correct the residual deformity. There were 2 cases of severe bowed-legs, the varus deformity still persisted post-operatively, but did not interfere with the function, and the patient did not want to have them corrected.

4. Stability

We concentrated mainly on medial and lateral instability of knees which caused valgus or varus defomity on weight bearing. There was a significant improvement after correction of the deformity by the prosthesis, and proper tightening of the collateral ligaments in every case.

In cases of severe valgus or varus deformity in which the cruciate ligaments were stretched, attenuated or partially torn, these knees remained unstable post-operatively, but they were less than the pre-operative status and did not interfere with the knee's function.

5. Walking capacity

We attempted to evaluate improvement of function and gait. Some patients continued to use the external supports because of associated joint involvement. There were 29 knees being unable to ambulate independently, needing some kinds of supports such as cane, crutches, wheel-chair. Among the remaining patients 25 knees were free from the walking aids considering particulary on the operated knee. It is considered to be an improvement of walking capacity in being able to bear more weight, walk a longer distance and the gait was more stable. By this criteria 76 knees showed improvement in the walking capacity, the rest was unchanged from the pre-operative status.

B. Final Results

1. Objective rating

By using the five criteria mentioned previously, 74 knees or 92% were rated as good, 6 knees or 8% were rated as bad.

The detail of the patients with bad result will be discussed later in the complications section.

2. Subjective rating of the effect of surgery or patient's appraisal

All the patients were asked to comment freely about the results of the operation by comparing the status of their knees before and after the operation. Seventy-five knees or 93% were improved, two knees or 3% were worse, and 3 knees or 4% were unchanged.

The primary basis for their rating was the relief of pain. They were not concerned greatly with their range of motion, stability, or deformity. Because the patient's rating was mainly on pain relief, the number of poor results were less than in the objective rating.

COMPLICATIONS

1. Requiring manipulation of knee under general anesthesia. Twenty-four knees or approxinately 30% underwent manipulation under general anaesthesia to obtain adequate range of motion. Most of these knees had range of motion of less than 60° at 1-2 weeks post-operatively. We have found that intra-articular injection of steroid at the time of manipulation resulted in less pain and facilitated the physical therapy

after the manipulation. Only one manipulation was required on these patients.

2. Infection

Post-operative infection developed in one knee who sufferred from gouty arthritis. The disease had flared-up post-operatively, and the knee was aspi rated and subsequently resulted in chronic drainage followed by secondary infection. The prosthesis had to be removed and arthrodesis was carried out.

3. Loosening of the femoral component of the prosthesis was documented in one patient.

This osteo-arthritic patient had persistent pain post-operatively inspite of good range of motion and stable knee. Therefore re-exploration of knee was performed, loosening of the femoral component of the prosthesis was found. Eventually this patient under went a hinge knee arthroplasty at another hospital.

4. Breaking of the tibial component of the prosthesis was found in one knee, which was severely bowed and very unstable.

The medial tibial plateau was markedly depressed with laxity of the collateral ligaments, and disappearance of the cruciate ligaments. In order to correct the varus deformity, the medial tibial plateau had to be built up with bone cement and buttress screws. Post-operatively patient did well for several months, finally the cross bar of the tibial component of the prosthesis was broken and the deformity had recurred. Anyhow this patient is still walking satisfactorily on this knee, and refuses to have it redone.

5. Fracture of the tibial spine occurred in one patient, due to a cut to remove the tibial plateau for inserting the tibial component of the prosthesis by using a hand osteotome. This probably would not happen if an electric saw was used. The knee had to be immobilized in full extension for 4 weeks to allow healing of the tibial spine fracture, which resulted in a poor knee flexion.

DISCUSSION

Initially, we have used both polycentric and geometric knee arthroplasties. Sub-sequently, only geometric knee arthroplasty has been used, this is due to the technical difficulty in inserting the polycentric prosthesis. The number of patients in this series is still small. Actually we have a large number of the patients who require knee arthroplasty, but they cannot afford the cost of the prosthesis. The period of follow-up observation is also too short to verify the results. Time, experience and careful review of patients are needed to evaluate fully the effectiveness of this type of prosthetic knee arthroplasty.

Adishian and Coventry[14] have reviewed 100 (Mark III) geometric total knee arthroplasties performed at the Mayo Clinic in 1975, loosening of the tibial unit was the most frequent complication, in which the incidence was 5 percent. They concluded that the loosening was most likely the result of a combination of factors including the patient's selection, surgical technique, design of the prosthesis, and the quality of the underlying bone. In this series no loosening of the tibial component was noted both clinically and radiographically, but the follow-up period is too short to be conclusive.

Insall et al[15] found that the result of geometric arthroplasty in osteo-arthritic knees were superior to knees with rheumatioid arthritis, but our experience did not support this statement.

None of the patients in this series complained of post-operative pain at patello-femoral joint, although the osteo-arthritic change was still present clinically and radiographically. Therefore it is doubtful to us that the prosthetic replacement for patello-femoral joint is necessary. We routinely shave and smoothen the patello-femoral joint while performing geometric knee arthroplasty.

Coventry et al[16] have reported that patients had either no pain or mild pain, with improved function in 92 percent, which was similar to our series.

Although most of the results reported in the series of geometric knee arthroplasty are encouraging, a large number of cases and a longer follow-up period is needed to verify this impression. We have found that activity or progression of the disease, motivation of the patient, long-standing flexion contracture of knee over 30, and severe instability causing marked lateral angulation of the knee, were the major factors leading to poor result. Involvement of the other joints to the extent that prevented post-operative exercise undoubtedly lowered the result. Bilaterality and their age did not effect the result.

Selection of patients is very important, one should limit the procedure to a knee that previously could have been managed by arthrodesis.

There has been no reports of disaster with this type of arthroplasty. If the arthroplasty fails, arthrodesis can still be performed without jeopardizing their results because minimal amount of bone was removed during insertion of the prosthesis.

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