

ACTA ORTHOPAEDICA SCANDINAVICA
SUPPLEMENTUM no. XXX

FROM THE ORTHOPAEDIC CLINIC, UNIVERSITY OF HELSINKI
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SKIN ARTHROPLASTY OF THE HIP JOINT AND
CORRESPONDING ALLOPLASTIC METHODS
IN THE LIGHT OF A CLINICAL STUDY

BY

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COPENHAGEN 1958

Printed in Finland
MERCATORIN KIRJAPAINO
HELSINKI 1958

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I. INTRODUCTION

The treatment of a painful and ankylosed hip joint comprises one of the main problems in orthopaedics. The weight-bearing hip joint is known to be an anatomically and statically difficult joint to reconstruct. For this reason many workers consider the treatment of choice to be arthrodesis of the hip or alteration of its statics by osteotomy. There will, however, always be individuals who are not content with this kind of treatment but desire a more movable hip joint. Thus the subject of arthroplasty can probably never be removed from the textbooks of orthopaedics. The numerous surgical techniques of different kinds described in the literature and the remarkable variability of the results obtained are evidence indicating that the question of hip arthroplasty should continue to be held open. Attention must therefore be given to efforts to study and develop new methods to solve this problem.

The method of skin arthroplasty developed in the Orthopaedic University Clinic of Helsinki and taken into use there in the spring of 1954 is an attempt in this direction. Since arthroplasty of the hip had earlier been performed in this clinic by alloplastic methods, it may be well to review simultaneously the results obtained with all the methods used. Since the surgical operations in nearly all the cases were performed by the same surgeon, this offers an opportunity to make comparisons between the results of vitallium cup and endoprosthesis arthroplasties and those obtained with the more recently performed skin arthroplasty. The present investigation has originated on this basis.

II. REVIEW OF THE LITERATURE

Attempts to mobilise ankylosed joints were made already at the time when asepsis was unknown and the means available for the alleviation of the pain caused by the operation were greatly deficient. The object at that time was not the reconstruction of the diseased joint, and the joint was either resected or a pseudarthrosis was made at a functionally suitable location.

The surgical procedures on the hip described below are now chiefly of historical interest only and are therefore reviewed mainly in the chronological order.

It is stated that already in 1769 CHARLES WHITE performed experimental resections of the femoral head on human cadavers. Fifty-two years passed before the same operation was made on a living subject. In the meantime, animal experiments had demonstrated that functionally useful joints could be obtained by resection of the femoral head. In 1821 ANTHONY WHITE performed this operation on a young boy, with a reportedly good result.

The first true arthroplasty of the hip on which adequate information is available is stated to have been carried out by JOHN RHEA BARTON on 1827. He had witnessed the strength and insensibility to pain of a false joint in many cases, but it was troublesome because it lacked the restraint of muscles. If a false joint could be artificially formed at a suitable point near the joint affected with bony ankylosis, the lost function of the joint might be compensated. With this in mind, BARTON performed the operation on a man with a severe hip joint deformity due to bony ankylosis following fracture. The femur was divided by sawing between the greater and the lesser trochanter. The operation was accomplished in 7 minutes. No ligatures were made and the wound was not sutured but only supported by adhesive plaster and slight dressings. When the wound was healing by granulation three weeks after operation BARTON began to make passive movements of the hip as often as the patient could endure. Active motions of the hip were begun three weeks later. In the eighth week the patient stood erect on crutches. Later there developed erysipelas with abscess formation in the wound, but

at the end of the third month the patient was able to walk with the aid of a cane and to sustain the weight of his body on the limb without pain. He had a movable false joint for six years, after which it gradually became rigid, but then in a better position.

RODGERS followed the principle of BARTON but he also resected a portion of the bone. To prevent re-ankylosis CARNOCHAN introduced the use of interposition material in 1840. He mobilised an ankylosed jaw by resection of the neck of the mandible, interposing a small piece of wood between the resected parts. In 1859 FOCK performed a radical resection of the femoral head and put the diaphyseal stump into the acetabulum. The wound became infected and healed only seven weeks later. The patient was allowed to walk with the aid of crutches ten weeks after operation. The operation brought relief from pain but the new joint was a flail joint and the use of crutches was necessary through life. In 1861 FOCK published 78 cases of extirpation of the femoral head performed by him; 26 of these patients died postoperatively. ZESAS (1888) reported that resection of the hip joint relieved pain but required the permanent use of crutches. At the end of the last century many renowned surgeons, among others HOFFA, MADELUNG, MIKULICZ and TRENDLENBURG, performed resections of the femoral head.

ROBERT JONES presented in 1908 a method of arthroplasty in which the greater trochanter was divided from the femur and fixed onto the femoral neck after osteotomy of the neck. The trochanter united with the stump of the neck and a kind of false joint was formed distally.

CHLUMSKY (1900) carried out animal experiments to find a suitable alloplastic material for interposition. He tried gold, silver, zinc, tin, magnesium, celluloid, rubber, collodium, decalcified bone and ivory but found that all of them caused a foreign body reaction with scar formation as the organism sought to free itself of the substance. CHLUMSKY believed that the proper alloplastic material would be found. WEGLOWSKI (1907) used cartilage, HOFMAN (1908) periosteum, BAER (1909) chromicised pig's bladder, SCHMERZ 6 (1911) amniotic membrane, KALOCZEK (1912) peritoneum, VON HACKER 6 (1919) hernial sac, LOEWE (1929) skin, and REHN (1934) steel. None of these materials gained wide use.

Interposition material from soft parts was first used by VERNEUIL (1860), OLLIER (1885) and HELFERICH (1894). OLLIER, in 1885, reported his work in a book describing rather extensively the details of the operation. The material first used was muscle, followed later by adipose tissue and fascia (HELFERICH, HOFFA, MURPHY). In 1905 MURPHY published his investigations, which were also based on animal experiments and attracted wide attention. He

used as interposition material flaps of muscle and fascia covered with a layer of adipose tissue and he had been able to mobilise hip, knee, elbow and temporo-mandibular joints.

His clinical experiences with arthroplasty MURPHY published in 1913. He had then performed 16 arthroplastic operations of the hip joint using flaps of fascia lata as interposition material, with success. He developed special instruments for formation of the hip joint. The articular surface of both bones was covered with the flaps of interposed material. After hip arthroplasty the lower extremity was held in marked abduction with about 10 kilograms weight extension. MURPHY began passive movements not earlier than one week after operation and in three to four weeks the patient was allowed to get up. In the performance of the operation he recommended a lateral incision and division of the tip of the greater trochanter from the femur. The tip was then replaced and fixed with metal wires. He stressed that arthroplasty is justified only in the hands of an experienced surgeon.

During the first half of the present century, a large number of arthroplastic operations were carried out, especially in Germany, where the most important results have been published by PAYR and LEXER. In 1910 PAYR reported good permanent results in only 10 out of 30 operations for mobilisation of joints. He nevertheless recommended arthroplasty provided special attention is paid to the selection of the patients and to stricter indications. In a paper published in 1914 he reviewed extensively his experiences with operations for joint mobilisation. He considered the removal of the joint capsule important from the point of both mobility of the joint and pain. A new capsule formed before long, permitting greater freedom of movement. After the transplantation of fascia a light-coloured, tendinous membrane formed on the joint surface, corresponding in function to cartilage. PAYR did not believe in the regeneration of cartilage; however, he considered functional stimulation and variation of the weight maximum very important for the joint. PAYR (1920) considered fascia the best material for interposition, although biologically it is a modest tissue. A large number of catgut sutures are necessary to enable early commencement of exercises. He also had his own method of hip arthroplasty, in which an extra-articular saddle joint was made in the femoral neck. Such a joint must be very strong and permit complete extension-flexion as well as a slight degree of ab-adduction.

SUMITA published in 1912 the results of his experimental investigations made in PAYR's clinic, where he had studied the fate of interposed soft part material following arthroplasty in experimental animals. The results were

good, the material was soon converted to a fibrotic mass, some kind of a synovial membrane was formed, and synovial folds even were observable. On the other hand, the cartilagenous covering did not regenerate and also the remaining islands of cartilage became fibrotic.

ALLISON and BROOKS (1913), also, did experimental work with animals and reached the conclusion that the interposition material is of secondary significance only, the greater part of it becoming necrotic, whereas the connective tissue that grows out from the joint surfaces is important. A similar result was also reached by PHEMISTER and MILLER (1918), and according to their investigations no difference was observed whether the flap was pedunculated or not, or whether there was any flap at all.

SCHMERZ (1916) considered a soft part interposition material unnecessary and alloplastic ones actually dangerous, since he held that coverings of the new joint surfaces are derived from exposed spongy bone.

SCHPELMANN (1917) spoke of so-called functional arthroplasty and sought to create as simple an articular mechanism as possible. Both SCHMERZ and SCHPELMANN emphasized the importance of shaping and smoothening the articular surface and the early commencement of frequent exercise. SCHPELMANN, also, considered interposed material unnecessary.

LEXER (1917), criticising SCHMERZ, pointed out the necessity of using interposed material. Smoothening of the joint surfaces is, of course, desirable, he stated, but interposition material, preferably adipose tissue, should be placed between the surfaces to prevent accumulation of blood in the joint spaces and consequent adhesions. LEXER had used wax and even oil as a lubricating fluid, but with poor results. In 1925 he published the results obtained in 92 cases of hip arthroplasty, describing 62 cases as good, 16 as poor and 14 as doubtful, but he did not state the criteria used. The most common indication (29 cases) had been ankylosis of the hip, second in frequency (21 cases) had been congenital dislocation of the hip joint in adults, and the third (19 cases) fracture or pseudarthrosis of the femoral neck. LEXER had also performed homotransplantation of complete joints with variable results, and GROVES had made attempts to replace the resected femoral head by beef bone, but the results were not promising. Arthroplasties of this kind have not gained acceptance among surgeons even in the presence of exceptional indications.

HASS (1925) did not find it necessary to retain the shape of the articular surfaces. He stated that the smaller the articulating surface, the less likely the re-ankylosis of the joint. He therefore sharpened the femoral head to a pencil point.

At the annual meeting of the British Orthopaedic Association in London in 1920, considerable disappointment was expressed in the results of arthroplasty of the hip. In most cases the pain had recurred, stability of the joint was poor, the mobility obtained decreased in a short time, and deformities developed (GROVES and PLATT).

BERGMANN published in 1928 his follow-up report on 17 hip arthroplasties. The pain of 13 patients had been relived but only 8 had even a relatively good mobility. BERGMANN considered that interposed material was not necessary.

In Finland, FALTIN (1927) had reached good results in 6 out of 12 patients but he recommended hip arthroplasty only for comparatively young persons and for elderly persons whose general condition is good. LANGENSKIÖLD (1944) was greatly disappointed in the hip arthroplasties which he had performed. Of his 15 cases, 4 had re-ankylosed already during hospitalisation.

Shortness of the femoral neck and weakness of the abductor muscles were already a long time ago found to constitute problems in connection with hip arthroplasty. Attempts have been made to increase the strength of the abductors by providing greater length to their bony leverage. ALBEE (1933) recommended vertical osteotomy of the greater trochanter to produce a lateral wedge, the intervening space being packed with bone chips. LEXER and WHITMAN fixed the trochanter more distally in the femoral diaphysis to obtain greater abductive power. They also removed the femoral head and shaped the neck stump, which they pushed into the acetabulum. This method had been successfully used especially in reconstructive operations of pseudarthrosis of the femoral neck (WHITMAN 1927, BRISTON 1934, LEXER 1931).

REHN (1934) reported 2 cases of hip arthroplasty in which he placed in the acetabulum a steel mold which was removed 4 weeks later.

After World War II a new epoch began in the development of hip arthroplasty. The method of operation which SMITH-PETERSEN had presented already in 1939 then began to receive increasing attention. His method is based on the fitting of a metal mold over the femoral head, permitting movement of the hip joint on both sides of the mold. In principle the method is still older, for already in the 1920's SMITH-PETERSEN had performed similar operations. However, the results then obtained were not satisfactory, as he had not found a suitable material for the mold. Glass was too fragile,

the same was true of pyrex, viscaloid produced a strong foreign body reaction in the tissues, and bakelite also was unsuited. When VENABLE and STUCK (1937) had demonstrated that a material called vitallium (an alloy of molybdenum, cobalt and chromium) is suitable for use in the human organism, SMITH-PETERSEN experimented with its use as a mold in arthroplasties performed by him. His intention originally was to remove the cup at a second operation, after the joint surfaces would have obtained the proper shape by means of the cup.

Reports on experiences with this method began to appear from time to time. KARLEN (1944), in Sweden, compared 9 cases of vitallium cup arthroplasty with 7 cases using fascia lata and stated that he preferred the old method. The results obtained by TAVERNIER and GODINOT (1945) were similar to those obtained by them earlier with fascia lata arthroplasty but they did not consider the removal of the cup necessary since it did not appear to be harmful. GADE (1947) published his experiences with arthroplasties made by the SMITH-PETERSEN method in the light of 54 cases followed up for $3\frac{1}{2}$ —4 years. He discussed separately the cases in which total extirpation of the capsule had been performed with those in which this had not been done. In regard to mobility and elimination of pain the results were definitely better in the first mentioned group. A drawback in vitallium cup arthroplasties, according to GADE, is bone atrophy and osteophytes developing around the cup, but he considered the method nevertheless promising. BERNTSEN and BERTELSEN (1952) obtained satisfactory results in only one-half of their 31 cases, and SHEPHERD (1954), in a series ten times as large, in only 40 per cent. RAMADIER and LEVITAN (1956) consider the vitallium cup arthroplasty a good method which gives lengthy relief in successful cases. In their series of 117 cases the postoperative observation time had been 6 months to 7 years.

A number of other reports have been published on the SMITH-PETERSEN arthroplasty and its modifications. I have been able to read the following: DEVAS 1954, WESTERBORN 1954, WESTERBORN, OLSSON and ALSEN 1954, BUXTON 1955, BOYD 1944, CAPENER 1956, AUFRANC 1957, and URIST 1957. Since AUFRANC's series is larger than those of the other investigators combined, I shall deal here only with his report. The series of patients was collected from the Massachusetts General Hospital, where SMITH-PETERSEN, developer of the method, worked. During a period of 15 years 1000 hip arthroplasties of the SMITH-PETERSEN type were performed, 193 of which were bilateral. Of the end results, 82 per cent were regarded as good or satisfactory, in 53 per cent there was very little or no pain, in 29 per cent

it was moderate and occasional, and in the remaining 18 per cent the pain was very considerable. No cane or other support was necessary on walking in 33 per cent of the unilateral and 15 per cent of the bilateral arthroplasties. Postoperative complications of various kinds occurred in 16.4 per cent of the cases.

Vitallium cup arthroplasty appeared to be very suitable in cases of congenital subluxation. Other indications mentioned were bony ankylosis, traumatic or degenerative osteoarthritis, fresh or old acetabular fracture, rheumatoid arthritis, »old septic hips», and sequels of unsuccessful arthroplasties. AUFRANC concluded with the following statement: »Mold arthroplasty is a sound surgical procedure; it needs, however, to be properly applied. Good to excellent results will be more frequent if the patients are managed according to the principles of bone healing and of muscle control.»

A noteworthy competitor to the SMITH-PETERSEN method of arthroplasty appeared in the resection-reconstruction operation devised by the JUDET brothers in France. The femoral head or a part of it was resected and replaced by an endoprosthesis made of the polymer of methylacrylic acid, a material which does not react to organic acids. The first prostheses broke, but greater strength was obtained by molding the acrylic around a chromium steel rod. At the time of publication of their method in 1950 the JUDET brothers had carried out 300 operations, the first cases being then 3½ years old. They reported excellent results. One-half of their patients were able to perform light work 2—3 months after the operation and the remaining patients in 6—8 months. The pain had disappeared or at least was relieved in 70 per cent of the cases and had not recurred in any of the cases. Flexion was 90° or more in 60 per cent, and less than 60° in 10 per cent of cases only. The internal and external rotation was generally about one-half of normal and in none of the cases was abduction less than 60°. However, they give no information on the preoperative condition of the patients. The diagnosis had been osteoarthritis, un-united fracture of the femoral neck, and non-tuberculous ankylosis. In short, the results appeared to be very good. Roentgenological examination had been made in 150 cases after an observation period of ½—3½ years and no prostheses were found to be loose. Previously the JUDET brothers had used the WHITMAN operation and had considered 60 per cent of the results poor.

By 1952 the JUDETS had performed 600 hip arthroplasties of this type. It was then observed that the acrylic prosthesis was not to be placed in the valgus or the varus position but in the normal position, and that the shaft of the prosthesis had to obtain support from the lateral cortex. In a series of

219 cases of osteoarthritis they reported excellent results in 17 cases, good in 47 per cent, fair in 19 per cent and poor in 17 per cent. A total of 77 cases of congenital (old) dislocations of the hip joint had been operated by the JUDET method, with good results in 30—35 per cent of cases.

Since the early results appeared excellent, it can be well understood that the method developed by the JUDET brothers gained increasing acceptance. Arthroplasties using endoprostheses began to be carried out to an increasing degree and on a wider range of indications.

In order that a consistent survey could be obtained of the experience gained so far, the American Academy of Orthopaedic Surgeons sent to its members and corresponding members a questionnaire concerning their experiences with prostheses of the femoral head. The results were known in January 1953. Although it was especially stressed that this was merely a preliminary review, the results obtained were noteworthy and indicative of the future course. The drawbacks of resection-replacement arthroplasty began to be clearly apparent, although the average observation period was only 10.3 months.

A total of 6156 prostheses of the femoral head had been fixed and they were of 37 different types. The survey revealed a very large number of complications. »The complications listed in this preliminary survey were appalling», it was stated, »and if a procedure cannot be done with fewer complications than those recorded, something is wrong.» It was also observed that the indications for the operation were too wide. The indications and contraindications were conflicting, a case which formed an indication for operation in the opinion of one surgeon being contraindicated in the opinion of another. Furthermore, the JUDET type of prosthesis was generally being discarded and substituted by intramedullary prostheses. The committee concluded the impressions which it had obtained from the preliminary survey with the words: »Many men have said that the promiscuous use of the device should be curtailed and that we should discipline the manufacturers and salesmen until better evaluation has been made. We do not see how we can discipline the manufacturers and salesmen. We think rather that each individual as a member of the Academy should discipline himself.»

The literature on endoprosthesis arthroplasties is an extensive one. New types of prostheses have been developed and the indications have been made stricter. Nevertheless enthusiasm towards endoprosthesis arthroplasties is continuously diminishing. There have been a large number of unsuccessful cases and their treatment has been extremely difficult. Breakage and loosening of the endoprostheses have occurred, fractures have developed,

the joints have again become ankylotic, and the patients have had odd sensations in the joint, not to speak of pain.

In the opinion of J. E. M. THOMSON (1956) the range of use of replacement arthroplasty is limited to certain types of hip trouble in aged persons. With the aged, brilliant results are not often obtained but their last years may be made more enjoyable and they will be less dependent on the help of other persons. He pointed out that an artificial material can never supplant a biological interposition material should such be found and prove suitable. He stated that he was interested in the skin arthroplasty method devised by KALLIO, concerning which he wrote as follows: »This bids me to believe that ultimately the problem of painful osteoarthritic hip may be solved by the use of our organic resources rather than by mutilation of the hip and metal devices.»

SCHOCH (1957) stated that according to the literature the good results obtained with arthroplasties of the JUDET type were usually about 50—60 per cent in the different series. Because of erroneous indications for the operation the method has been seen in a less favourable light than it deserves. It will undoubtedly retain a place in orthopaedic surgery provided the indications are judged correctly. This opinion becomes apparent also from other publications which I have read, a more detailed review of which is not, in my opinion, necessary in this connection (*e.g.*, McBRIDE 1952, KIAER 1952, BUXTON and WAUGH 1954, COLLINS 1954, CREGAN 1954, DEBEYRE and DOLIVEUX 1954, DEVAS 1954, HECK and CHANDLER 1954, LEVY *et al.* 1954, MENDELSON and ALBAN 1954, MERLE d'AUBIGNE and POSTEL 1954 and 1956, SHEPHERD 1954, WESTERBORN *et al.* 1954, BUXTON 1955, COMPERE 1955, DAY and HINCHEY 1955, GUILLEMINET and JUDET 1955, GUILLEMINET and MARION 1955, MCAUSLAND 1955, MCKEEVER 1955, MENDELSON and BECKER 1955, O'BRIEN 1955, STREET 1955, THOMPSON 1955, ALSEN and OLSSON 1956, BOYD 1956, CAPENER 1956, MERLE d'AUBIGNE and MAURER 1956, THOMSON 1956, LIPPMANN 1957, MOORE 1957).

The variety of types of alloplastic arthroplasty mentioned in the literature serves to indicate that a fully suitable biological method has not been found. It is therefore rather surprising that practically no attention has been paid to skin, which is a readily obtainable material of high plastic properties. Apprehensions may have been felt concerning the development of infection, epithelial cysts or even malignant degeneration. It is a well known fact that skin cannot be rendered completely free from bacteria and that epithelial cysts may develop when epidermis is introduced into the deeper layers of tissue. There is also COHNHEIM's old theory of »aberrant germs». For some

reason or other the use of skin as interposition material in arthroplasty appears to have been limited to a few cases only.

In 1913, LOEWE used skin for tendon repairs and plastic operations for hernia. He published in 1929 his extensive experiences with the use of skin. In this connection he mentioned two cases in which he had used skin as interposition material in the formation of a new hip joint. He performed a high subtrochanteric osteotomy and placed a pedunculated skin flap between the bone surfaces to produce a pseudarthrosis. He pointed out the importance of thoroughly removing the epidermis by scraping to prevent the development of a fistula at the pedicle, as had occurred in one of his cases. LOEWE also had mobilised the knee joint, using skin for interposition. In summarising his experiences he recommended skin from which the epidermis had been removed, for use for all purposes for which the use of fascia had been possible in reconstructive surgery. At this time, fascia had already found wide use (*e.g.*, DENK 1912). The first to carry out a comprehensive study of the use of skin in surgery was REHN. In both animal experiments and clinical studies he has been able to demonstrate that skin is highly suitable for functions of various kinds in reparative surgery, such as plastic operations for hernia and tendon repairs. By functional irritation the skin became adapted to its new situation and converted to a tissue of the type that it was intended to replace (REHN 1914, 1931). Some investigators have considered skin superior to fascia (REHN, EITNER, EITEL). A number of drawbacks in the use of fascia were enumerated by MAIR (1945), who mentioned, for example, that in about 25 per cent of the cases there had developed at the lateral side of the thigh a painful condition which could be very troublesome although it had no connection with development of a muscular hernia.

MAIR recommended a whole-thickness skin graft, placing, however, particular emphasis on its extremely thorough cleaning. After careful depilation, the skin was washed with soap and warm water for 10 minutes. Alcohol compresses and a sterile double hip spica bandage were then placed on the skin and changed daily during three days. Only after this process was the skin fit for use as a graft. MAIR also sprinkled sulfa powder on the graft.

BROWNE (1951) was astonished by the resistance of the skin graft to infection. Although in one case the free graft remained in an infected wound for three months it retained its vitality.

After LOEWE (1929), skin grafts as interposition material in arthroplasty were used by PAIS (1948) in mobilising digital joints. LOGROSCINO (1950) wrapped a mantle of cutaneous adipose tissue around the femoral neck

when performing surgery for ankylosis of the hip following acetabular fracture. In three cases of hip arthrosis, PASQUALI (1951) placed a free skin flap over the head of the re-shaped femoral stump, with good early results. FIUME (1952) also obtained by the same procedure a favourable result in a case of rheumatoid arthritis of the hip joint, and DELCHEF *et al.* (1955) in a case of arthrotic hip.

BÄTZNER (1951) described 276 cases of various plastic operations using, skin transplants, performed in the Surgical Clinic in Freiburg; in seven of these cases skin was employed as interposition material in joint operations. MCGRAW *et al.* (1956) reported four cases of arthroplasty of the knee in which skin grafts had been used successfully for interposition. LOEFFLER (1956) had used scrotal skin for the same purpose in male patients.

Animal experiments with arthroplasty using skin grafts as interposition material were performed by PEREGALLI (1950) on rabbit elbow joints and DEMARCHI *et al.* (1953) on rabbit knee joints. Both reported favourable results.

Concerning the question of disinfection of the skin in surgery, NOGUCHI (1912) already reached the conclusion that it is neither possible nor necessary to render the skin free from all bacteria. The important factors are that pathogenic bacteria are removed and that the skin is intact. The usual cleaning of the skin in surgery would, he stated, be adequate. SAARENMAA (1946) reached the same conclusion in his studies of the bacterial flora of the skin. Even a high saprophytic bacterial content will not endanger the surgical procedures. On the other hand, it has not been possible to demonstrate that the skin would have any noteworthy self-disinfecting power (HELLAT 1948).

LOEWE, KALLIO and LOEFFLER cleaned the skin intended for interposition material in exactly the same manner as the skin over an area to be subjected to surgical operation. There has been some divergence of opinion as to whether or not the epidermis should be removed from the skin graft by scraping. Scraping of the epidermis to expose a fresh surface was considered to be sufficient by LOEWE, GIEGERICH and LOEFFLER, while REHN and BÄTZNER removed it more carefully with a Thiersch knife. HARKINS, MAIR and CHODOFF, on the other hand, left the epidermis intact. KALLIO also has not regarded the removal of the epidermis necessary. In a part of the cases, however, he scraped the epidermis with a knife to obtain a fresh, bleeding surface.

When Professor K. E. KALLIO first began to use whole-thickness skin as interposition material in arthroplasty, he had never seen skin arthroplasty performed nor even heard or read of such cases. He did not wish to attempt such arthroplasties without previous animal experimentation. He therefore suggested to Dr. R. KIVILAAKSO as the subject of an academic thesis the study of possible changes occurring in whole-thickness skin grafts buried in tissue. KIVILAAKSO therefore studied the subsequent events of such skin grafts used for repair of defects in the Achilles tendon and the abdominal wall. His experiments with rabbits demonstrated that the organism had converted the tissue of mesodermal origin into an organic part of itself, but at the same time had destroyed that portion of the graft which was ectodermal in origin. Dr. K. O. KETTUNEN, resident of the Kallio clinic has recently performed, as his academic thesis work, skin arthroplasties in the hip joints of cats, with special attention to metaplasia of the connective tissue. His experiments showed that as a result of pressure and function of the joint the interposed connective tissue was replaced by metaplastic articular cartilage of fibrous or hyaline type. In the control series the joint surfaces were of sclerotic bone. KIVILAAKSO published the results of his studies in 1955 and KETTUNEN his final results in 1958.

Since it had been demonstrated in animal experiments that whole-thickness skin is serviceable and since subsequent clinical experience appeared favourable, an increasing number of skin arthroplasties have been made at the University Clinic for Orthopaedics and Traumatology in Helsinki. In presenting his new method at l'Academie de Chirurgie in Paris in the spring of 1955, KALLIO already had a series of 21 cases. New cases have been added since then and further experience has been gained (KALLIO 1955, 1956, 1957). By today the whole material comprises 107 cases. The cases of skin arthroplasty of the hip joint in which, by the summer of 1957, 2—1 year had passed since the operation form a part of the material of the present investigation.

III. STATICS AND MECHANICS OF THE HIP JOINT

In consideration of the extensive literature on arthroplasty of the hip joint which has been published during the past few decades, it is an unexpected fact that very little attention has been paid to the statics and mechanics of this joint. An understanding of these physical factors is indeed of the greatest importance especially in reconstructive surgery of the hip joint. Walking in the erect posture is a heavy burden on the hip joints owing to their structure (PAUWELS, DEBEYRE and DOLIVEUX, BLOUNT and CAPENER).

A ball-and-socket joint, such as the hip joint, has three axes of movement. The joint surfaces are very regular and bear a greater resemblance to geometric surfaces than those of any other joint. The neck of the femur has an average length of about 4 cm and forms an angle averaging 127° (extreme values $115-140$) with the femoral diaphysis and an angle averaging 15° (extreme values $4-20$) with the intercondylar line of the femur (VON LANZ, WACHSMUTH).

In the erect posture the hip joint has to bear only the weight of that part of the body which is situated above it. On walking or running, each hip joint in turn is responsible for the weight of the whole body, from which is deducted the weight of the supporting lower limb but to which is added the muscular power required to maintain equilibrium and the additional power produced by movement.

The weight-bearing area of the femoral head forms the fulcrum of a two-armed lever, on one end of which is applied the weight of the body and on the other end the abduction power of the abductor muscles necessary for maintenance of equilibrium (fig. 1). Let us assume that when a step is taken the weight of the body at point A is power P. (Point A then lies slightly contralateral to the median line, as shown in the figure.) The weight-bearing area of the femur is designated by point B and the point of effect of the abductor muscles by C. When the power of the abductors is V, then the total of these powers $P + V$ acts on the fulcrum. Thus $BC - V = AB - P$.

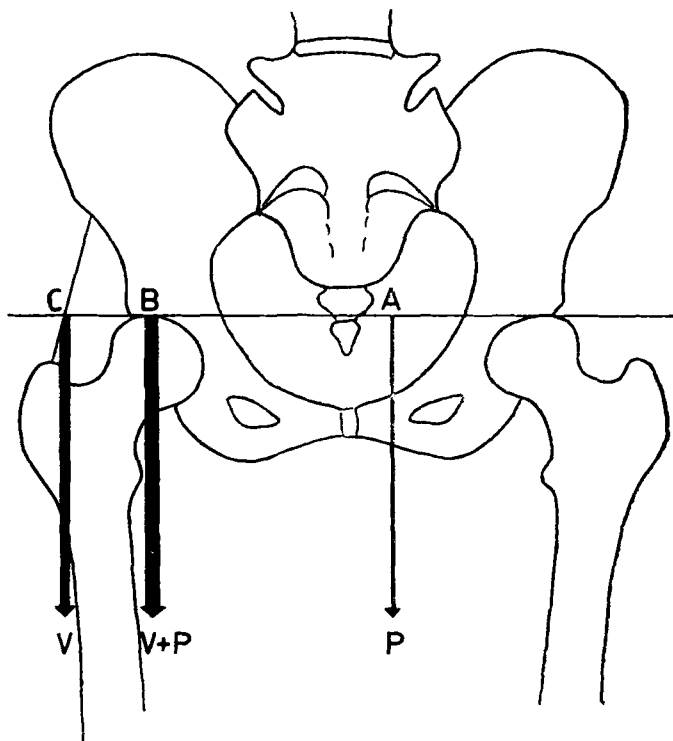


Fig. 1.

Assuming that BC is one-third of AB (according to DEBEYRE and DOLIVEUX, the average length of BC has been calculated by PAUWELS to be 4 cm and that of AB 11 cm), then $BC = AB/3$ and consequently $V = 3P$, which means that the effective power at fulcrum B is equivalent to 4 times the body weight.

According to VON LANZ and WACHSMUTH, the cartilagenous covering of the acetabulum has an area of, on an average, 16 sq.cm. Assuming that an area equal to the total acetabular cartilagenous surface participates in the weight-bearing at the femoral head, the pressure in kilograms per square centimetre may be calculated as follows:

$$\text{Pressure per sq.cm.} = \frac{\text{Weight to be borne}}{\text{Weight-bearing area}}$$

$$\text{Example:} \quad \frac{4 \cdot 70}{16} = 17.5 \text{ kg/sq.cm.}$$

If the hip joint is in such a position of subluxation that the weight-bearing area is only one-fourth of normal in size, the pressure per square centimetre of joint surface is 70 kg. With the femoral neck in the valgus position the corresponding arm of the level is shorter and the required abductive power greater, thus increasing the pressure further.

We may readily understand that cartilage is unable to bear excessive weight without being destroyed. The joint becomes painful, the pain compels the patient to limp, limping burdens other joints and the spine, and the situation is aggravated.

There are various types of limp. CALVE, GALLAND and Cagny, in 1939, published an interesting study on limping. They claimed, for instance, that a difference in the length of the lower limbs causes limping only when it is 3—4 cm or more. Smaller differences can readily be compensated by hip movements. In this connection it may be well to discuss briefly the mechanism of limping due to pain, since it has a direct bearing upon questions relating to arthroplasty.

It is selfevident that the patient will make an effort to shorten the step which causes pain. This is followed by a longer step with the sound limb. However, limping due to pain is not quite as simple as this. According to CALVE *et al.*, the patient, before placing his weight on the painful hip joint, inclines by reflex movement his body towards the painful side. The centre of gravity of the body thus is transferred nearer the fulcrum and the abductors are not called upon to exert so great a force as normally to prevent inclination at the hip. When the body is sufficiently inclined towards the painful side, only the weight of the body above the hip rests upon the femoral head, whereas the abductors are idle. Such a limp naturally relieves the burden on the hip joint and from this aspect is beneficial. However, the inclination movement is a strain, especially for persons of advanced age, and causes additional distress. A common sequel is low-back pain.

It is possible, however, to relieve the load upon the hip joint without limping. A very simple mechanical aid is the cane, as was pointed out by, *e.g.*, CALVE *et al.* (1939). Recently attention has been drawn to it by BLOUNT (1956) in his excellent paper «Don't Throw Away the Cane!» delivered before the American Academy of Orthopaedic Surgeons in January 1956. When the cane is held on the side of the sound hip, heavy leaning is not required before the cane will relieve considerably the load on the hip because of its long leverage. PAUWELS calculated that on walking a medium-sized person places upon his hip an average weight of 175 kg. When, instead, he leans on a cane held in the opposite hand with a weight of 9 kg, the load on the hip is

reduced to 100 kg. BLOUNT therefore advised that the patient who has undergone arthroplasty should continuously use the cane, and he stated: »This makeship hip is good for five years if you are enough of an acrobat to walk without a cane; it is good for ten years if you are smart enough to cut down on the stress that you put on this artificial joint.»

PAUWELS perhaps was the first to realize the significance of the stress on the hip joint. He suggested, for instance, performance of the so-called adduction osteotomy of the femoral neck, which would shift the load to another area of the joint and at the same time lengthen the leverage of the abductors. In this operation, a wedge is resected from the base of the femoral neck, which then is placed in the varus position. PAUWELS claimed that the joint space then gradually becomes more distinct, as a sign of regeneration of the cartilage, and that the pains disappear. He presented this method especially for the treatment of subluxation and coxa valga luxans, claiming that he had obtained good results in all of his 41 cases.

The static and mechanical factors in the hip joint may be summarised as follows. The hip joint is subject to a very great mechanical stress. The smaller the weight-bearing area in the joint, the greater the risk of degeneration of the cartilage due to excess pressure. The length of the femoral neck is of essential significance in regard to the stress on the hip joint. Great strength is required of the abductors. A cane is a definite aid which will relieve the excess load on the hip joint.

IV. THE PROBLEMS

It was the object of the present investigation to seek answers to the following questions:

1. To what extent has it been possible to relieve the patient's pain by the different types of arthroplasty referred to in the foregoing?
2. To what extent has it been possible to increase the range of movement of the hip joint by the different arthroplasty methods?
3. What has been the opinion of the patients concerning the results obtained?
4. What would appear to be the relationship of the three different arthroplasties to each other?
5. What can be said in the light of the present investigation concerning free whole-skin grafts used as interposition material in arthroplasty?
6. In what cases does hip arthroplasty appear to be worth performing and which one of the different methods would be most suitable in each particular case?

V. MATERIAL AND METHODS

The series comprises all cases of arthroplasty of the hip joint performed in the Helsinki University Clinic of Orthopaedics and Traumatology during a period of 7 years (July 1, 1949—June 30, 1956). The follow-up time varied from 1 to 7 years. During the stated period 171 hip arthroplasties were performed on 163 patients. One surgeon (Professor K. E. Kallio) performed 158 of these operations, and four surgeons the remaining 13 operations. Bilateral arthroplasty was performed on 8 patients, as follows: Endoprosthesis-vitallium cup arthroplasty in 3 cases, endoprosthesis-skin arthroplasty in 2 cases, and bilateral endoprosthesis arthroplasty in 1 case. A total of 108 arthroplasties were made on 103 females and 63 arthroplasties on 60 males. The left hip was operated on in 86 cases and the right hip in 85 cases. The oldest patient was aged 77 years and the youngest 12 years. A distribution of the cases by calendar years and surgical methods is shown in table 1.

Table 2 shows a distribution of the patients by age groups.

The patients are distributed according to diagnosis in table 3.

The causes of secondary osteoarthritis are listed in table 4.

TABLE 1. — *Yearly Distribution of Arthroplasty Operations*

	Vitallium Cup	Endo- prosthesis	Skin Arthroplasty	Total
July 1—Dec. 31, 1949	2	—	—	2
1950	3	—	—	3
1951	1	3	—	4
1952	4	32	—	36
1953	7	25	—	32
1954	11	21	9	41
1955	5	2	29	36
Jan. 1—June 30, 1956	2	—	15	17
Total 7 years	35	83	53	171

TABLE 2. — *Age Distribution of the Patients*

Age	Vitallium Cup	Endo-prosthesis	Skin Arthroplasty	Total
10—19 years	1	—	1	2
20—29 „	4	1	1	6
30—39 „	6	11	6	23
40—49 „	13	21	13	47
50—59 „	6	28	22	56
60—69 „	4	20	10	34
70—79 „	1	2	—	3
Total	35	83	53	171

TABLE 3. — *Distribution of Series by Diagnosis*

Diagnosis	Vitallium Cup	Endo-prosthesis	Skin Arthroplasty	Total
	Cases	Cases	Cases	Cases
Primary Osteoarthritis	13	39	32	84
Secondary Osteoarthritis ..	18	38	20	76
Tuberculosis	3	1	1	5
Fracture of femoral neck	—	4	—	4
Ochronosis	1	—	—	1
Condition after arthroplasty	—	1	—	1
Total No. of cases	35	83	53	171

TABLE 4. — *Causes of Secondary Osteoarthritis*

Diagnosis	Vitallium Cup	Endo-prosthesis	Skin Arthroplasty	Total
	Cases	Cases	Cases	Cases
Dysplasia	10	4	7	21
Rheumatoid arthritis	1	12	7	20
Coxa vara adultum	1	10	1	12
Trauma	5	5	1	11
Protrusion of acetabulum ..	—	4	2	6
Non-rheumatic arthritis ..	1	2	1	4
Spondylarthritis ancylopoetica	—	1	—	1
Coxa plana	—	—	1	1
Total No. of cases	18	38	20	76

Primary osteoarthritis is used in the present investigation to designate idiopathic osteoarthritis of unknown etiology. It is seen from table 4 that dysplasia was the most common cause of secondary osteoarthritis. The cases in the dysplasia group were selected according to the criteria presented by LLOYD-ROBERTS (1955). It includes all the developmental anomalies of the acetabulum and the femoral head and neck which simulate the changes occurring in congenital dislocation of the hip joint.

Rheumatoid arthritis was regarded as the cause of secondary arthrosis in those cases in which the case history included rheumatic fever and in which damage by the disease could be seen in a several number of joints. The basic cause of adult coxa vara was an evident epiphyseolysis of the femoral head at an early age. Trauma was stated to be the cause of secondary arthrosis in 11 cases. In these cases the trauma had been very severe, resulting in damage of the femoral head, fracture of the acetabulum, or dislocation of the hip joint. There was one case of neuropathic arthropathy due to a trauma of the spinal cord. This case has been reported in a previous paper from this Clinic (KETTUNEN 1957). The cases of acetabular protrusion, non-rheumatic arthritis, ankylosing spondyl-arthritis and coxa vara need not further comment in this connection.

Fractures of the femoral neck were all fresh subcapital fractures. The case of alkaptonuria associated with ochronosis was diagnosed only after the surgical operation was made; it has been described in a separate paper (E. KALLIO 1955). The post-arthroplastic condition mentioned in the table 4 refers to an unsuccessful vitallium cup arthroplasty performed in another country.

In studying the cases of arthroplasty in the present series I proceeded as follows. After all the case reports were read, a questionnaire was sent to the patients and they were also invited for a personal follow-up examination. Having served as a surgeon in the Orthopaedic Clinic for a total of 18 months between 1952 and 1956, I had been in a position to see a large proportion of these patients both before the arthroplasty was performed and during the operation. I did not perform any of these arthroplasties, but I assisted or attended at 43 operations, which was equivalent to 25 per cent of the operations in this series.

The patients' postoperative condition may be considered to be amply and reliably covered by the answers to the questionnaire. The patients were allowed to weigh their answers at length at home without being exposed to suggestive comment.

For personal examination of the patients I devoted the Saturday of each

1. For how long did you feel pain in the hip?
..... years months
2. When did the pain occur?
At rest (on sitting or lying down)
On movement: When starting to walk
When walking
After walking
3. Did the pain disturb your sleep?
4. Did you use pain-allaying drugs? For how long?
5. What kind of work could you perform despite your distress?
6. Were you quite incapable of working?
7. How did you walk before the operation?
With cane
Without cane
On crutches For how long?
Incapable of moving? For how long?
8. What distance could you walk without stopping?
Less than 100 metres
Less than 500 metres
Less than 1000 metres
More than 1000 metres
9. Were you able to ride a bicycle?
10. Did you have difficulty in putting on your shoe or sock/stocking?
For how long?
11. Was the other hip sound?
If not, how was it affected?
For how long?
12. Were your knees sound?
13. Did you have back pain which was severe enough to trouble you at work?
14. What is your length? cm (approximately)
What is your weight? kg (approximately)

14. What is your personal opinion concerning the operation?

Very satisfied

Satisfied

Cannot say

Dissatisfied

15. Have you anything more to tell about your hips?

I received 161 replies on the questionnaire form. This corresponds to 94 per cent of all the cases. Further it was learned that 4 patients had died. There remained 6 patients only on whom no follow-up information was obtained. Table 5 shows the patients with different types of arthroplasties distributed according to the response to the follow-up questionnaire.

TABLE 5. — *Follow-Up Examinations*

	Vitallium Cup		Endo-prosthesis		Skin Arthroplasty		Total	
	No. of Cases	Per Cent	No. of Cases	Per Cent	No. of Cases	Per Cent	No. of Cases	Per Cent
Personally examined	39	86	65	78	47	89	142	83
Replied to questionnaire	34	98	75	90	52	98	161	94
Dead	0	0	3	3.6	1	1.9	4	2.4
No information	1	2	5	6	0	0	6	3.6
Total No. of cases	35		83		53		171	

In the personal follow-up examination, attention was first paid to the patient's gait, Trendelenburg's test was made, and the range of movements of both hips was measured with a goniometre. With the patient lying supine on the hard examination table, a possible flexion contracture was first measured by the well-known Thomas's test, the opposite hip joint sufficiently in flexion to retain the physiological lumbar lordosis. This was checked by passing the examiner's hand under the lumbar spine. Both the active and the passive motions were measured. Generally there was no noteworthy difference between these motions. The mobility index was calculated according to the active movements. Extension-flexion, abduction-adduction, and internal-external rotations were measured with the patient on his back on a hard base. The abduction and adduction were measured with the hip joint at extension of 180° but the rotations at flexion of 90° or, if this was not possible, at the maximum flexion. Hyperextension was not considered, since the case

reports did not state the preoperative hyperextension and it thus was unknown in the majority of cases.

Roentgenograms were made of all the patients in connection with the personal examination. Both hip joints were taken on the same film in the anteroposterior projection. Roentgenograms were also made according to Lauenstein, with the hip in flexion of 135° , in maximal abduction, and in median rotation if possible. I personally examined the roentgenograms of all the patients. They were usually taken at the following times: A. Before the operation, B. About 1—4 weeks after the operation (control), C. Later at various intervals. Special attention was paid to the preoperative roentgenograms, and the postoperative control roentgenogram was compared with the last one available for each patient.

VI. PREOPERATIVE FINDINGS AND OPERATIVE INDICATIONS

Out of the 171 cases only two were entirely painless preoperatively, the sole purpose of the arthroplasty then being the creation of a movable joint. This, of course, excludes fractures of the femoral neck, which were immediately operated on, in four cases.

TABLE 6. — *Preoperative Data*

	Vitallium Cup		Endoprosthesis		Skin Arthroplasty	
	Years	Cases	Years	Cases	Years	Cases
History of pain	6.7	(34)	8.8	(73)	7.3	(52)
Use of analgesics	6.2	(16)	3.7	(40)	5.3	(32)
Difficulty in putting on shoe and sock	4.7	(23)	5.5	(48)	4.7	(36)
Inability to work	1.2	(14)	2.4	(28)	3.9	(23)

Table 6 shows the duration of the history of moderate or severe pain in the affected hip. The figures in parentheses state the number of patients who were able to inform the exact length of time and on whom the average figures are based.

Other preoperative data in the case histories will be seen from table 7. This information has been taken from the replies given by the patients on the questionnaire, and has been supplemented where necessary with data from the hospital record. The figures are percentages of the total number of cases stated in the heading of each column.

Table 7 reveals that the preoperative case history had been similar, on the whole, in the different arthroplasty groups. Attention is drawn in particular to the large number of patients who had pain both in the knees and the back. It cannot readily be stated what rôle the limping caused by the hip disease played in this distress. It seems evident that the limp caused by dis-

TABLE 7. — *Preoperative Data*

	Vitallium Cup (34 Cases)	Endoprosthesis (75 Cases)	Skin Arthroplasty (52 Cases)
	Per Cent	Per Cent	Per Cent
Occurrence of pain	100	94	98
At rest	62	69	75
On starting to walk	100	92	85
On walking	97	91	90
After walking	83	75	65
Pain disturbed sleep	65	73	75
Patient used analgesics	68	76	73
Incapable of work (at least occasionally)	41	37	44
Manner of walking:			
Without cane	50	47	61
With cane	47	37	35
With crutches	3	16	4
Distance walked without stopping:			
Less than 100 metres	32	37	42
" " 500 " 	32	33	31
" " 1000 " 	15	10	12
Over 1000 "	21	20	15
Able to ride bicycle	35	41	50
Difficulty in putting on shoe and sock	97	89	87
Opposite hip also affected	29	35	52
Knees also affected	41	43	40
Back pain disturbing work	56	55	60

ease of the hip joint will, in any case, increase the stress on the back and knees and thus tend to aggravate any changes already existing.

The mobility of a joint before and after operation is naturally an important criterion of the success of arthroplasty. GADE presented in 1947 a specially devised mobility index to express the mobility of a joint with one figure. GADE's index is, in my opinion, well judged and takes into account the functional value of the movements, for all movements are not equally valuable in practical life. This index was used by SHEPHERD (1954), among others, in his extensive follow-up investigation of 650 cases of hip arthroplasty. GADE's mobility index is calculated for the hip joint according to the following diagram:

Flexion:

- Multiply first 45° by 0.6
- » following 45° by 0.4
- » following degrees by 0.2

Hyperextension:

- Multiply full range of motion by 0.2

Abduction:

- Multiply first 15° by 0.6
- » following 15° by 0.4
- » following degrees by 0.1

Adduction:

- Multiply full range of motion by 0.2

External rotation:

- Multiply first 30° by 0.3
- » following degrees by 0.1

Internal rotation:

- Multiply full range of motion by 0.2.

The normal value for a young person is about 100. A calculation of the mobility index according to the degrees of movement informed by the American Academy of Orthopaedic Surgeons for a normal hip joint will give the index figure of 94.5. If hyperextension is excluded, as is done in my series of cases, the normal index figure will be 86.5. This accordingly would be the ideal value for the present series. The normal value for an aged person, even if in good health, cannot be as high as this. SHEPHERD states that 55 is excellent for an elderly person.

Table 8 shows the distribution of the present series according to the mobility index figures and the mean index figures in the different arthroplasty groups before performance of the operation.

Of the preoperative mobility index figures, those in the skin arthroplasty group are the most reliable. The goniometre has been more regularly used in the Clinic since 1954 for measurement of the mobility of the hip joint, and the values on the hospital records prior to 1954 were largely visual estimates only.

All the roentgenograms available on the series were examined. It was revealed that bilateral roentgenological changes were present in the hip joints in 88 cases. In the remaining cases one of the hip joints was normal

TABLE 8. — *Distribution of the Preoperative Mobility Index Values*

Index Value	Vitallium Cup	Endo-prosthesis	Skin Arthroplasty	Total
	Cases	Cases	Cases	Cases
0— 9	13	23	11	47
10—19	7	22	8	37
20—29	5	14	13	32
30—39	3	7	13	23
40—49	4	3	2	9
50—59	1	3	4	8
60—69	1	2	1	4
70—79	0	0	0	0
80—89	0	0	1	0
90—99	0	0	0	0
Total No. of cases	34	74	53	161
Mean index value	20.3	18.3	26.3	21.3

roentgenologically. Examination of each group separately disclosed changes in both hip joints as follows: In 11 cases, or 31 per cent, of the vitallium cup arthroplasty group; in 38 cases, or 46 per cent, of the endoprosthesis group; and in 29 cases, or 55 per cent, in the skin arthroplasty group.

In 111 cases a comparison could be made with the roentgenograms taken before the arthroplasty operation, as was done by GADE (1947). The findings revealed by this comparison are shown in table 9. Naturally an estimate of the mineral content of the articular bone structure is extremely difficult on the basis of the ordinary roentgenogram. The estimation was performed by placing all the available preoperative roentgenograms on one large illuminated glass sheet and the joint in question was compared with the opposite joint if this was healthy; otherwise it was compared with the bone structure of the pelvis and the diaphysis of the femur. If the mineral content of the hip joint appeared to be very clearly increased, the hip joint was termed sclerotic. If bone atrophy was fully evident, it was labelled atrophic. Indefinite cases were designated as indifferent. Osteophytic cyst and «bone ridge» formations were regarded as positive only if very clear. Abduction-flexion roentgenograms in the Lauenstein position were also taken into consideration.

The so-called Wiberg's CE angle was measured from the preoperative roentgenograms of the patients with osteoarthritis. The values obtained are shown in table 10. As is well known, this angle has been used in estimating the structure of the hip joint from roentgenograms.

TABLE 9. — *Some Findings in Preoperative Roentgenograms*

	Vitallium Cup (26 Cases)	Endo- prosthesis (45 Cases)	Skin Arthroplasty (40 Cases)	Total (111 Cases)
Bone structure of joint:				
Sclerotic	18	24	18	60
Indifferent	7	21	21	49
Atrophic	1	0	1	2
Osteophyte formation:				
In acetabulum and femoral head	22	41	30	93
In acetabulum only	2	1	1	4
In femoral head only	0	3	4	7
Cystic formation:				
In acetabulum and femoral head	7	18	14	39
In acetabulum only	0	0	1	1
In femoral head only	8	3	5	16
Bone ridge formation	5	2	15	22
Exceptionally short femoral neck	6	8	4	18

TABLE 10. — *CE Angles Measured from the Roentgenograms*

CE Angle	Vitallium Cup	Endoprosthesis	Skin Arthroplasty	Total
	Cases	Cases	Cases	Cases
Over 25°	10	23	24	57
20°—25°	6	16	7	29
Under 20°	10	6	9	25
Total No. of cases	26	45	40	111

The CE angle was used, among others, by HERMODSSON (1947) in the classification of osteoarthritis of the hip joint into two types, *i.e.*, median and proximal, and by LLOYD-ROBERTS (1955) in studying dysplasia of the hip joint. The CE angle of a normal hip joint is wider than 25°, values of 20—25° are borderline cases, and those below 20° are pathological, being a sign of a deficiently developed acetabulum. The CE angle is, according to HERMODSSON, »the angle that a line drawn from the outer and upper edge of the acetabulum to the centre of the femoral head makes with a vertical line drawn at right angles to the horizontal between the centres of the femoral

heads.» Since the CE angle is not always readily determined by these criteria, HERMODSSON's instructions for determination of the angle in indefinite cases followed in the present work.

Thus we observe that slightly over one-half of the preoperative roentgenograms of the patients with osteoarthritis had a normal hip joint structure as far as the CE angle was concerned.

In evaluating the indications for hip arthroplasty, a number of factors must naturally be considered. An important fact is the occupation of the patient. The present series was distributed according to occupation as follows, judged according to the strenuousness of the work:

Intellectual work or light manual work	81 patients
Farm work	55 »
Other manual work	35 »
Total	171 patients

In each case the surgeon discussed with the patient what bearing the increased or unchanged mobility of the hip joint would have on his occupation. Nearly all the patients preferred a mobile joint even at the expense of moderate pain. Even in such cases an arthroplasty was not the only procedure suggested. Table 11 lists the other operations, including arthrodesis, which were performed in the Clinic on patients with hip trouble during the same period.

TABLE 11. — *Hip Operations Other than Arthroplasty Performed during the Same Period as the Arthroplasties in the Present Series*

Operation	No. of Cases
Denervation	84
Intertrochanteric osteotomy.....	64
Subtrochanteric osteotomy	26
Acetabuloplasty	19
Capsulectomy	17
Arthrodesis	11
Arthoplastic resection	2
Total No. of cases	223

In addition to the patient's occupation, his general physical and mental condition was also taken into consideration, especially with a view to successful postoperative care. If the discomfort was bilateral, it was considered to be

an indication for mobilisation of at least one hip. The patient's age was generally not a decisive factor in considering the general indications for operation. Since the number of patients in need of operation has been large, it has been necessary to limit the hospitalisation period to the minimum. Hence the after-treatment of the arthroplasties could not be the best possible. Since the patients live widely spread over our sparsely populated country, follow-up examinations in the Clinic's out-patient department could not be very efficiently arranged. Factors such as these have influenced not only the consideration of indications but also the results obtained.

VII. OPERATIVE TECHNIQUE AND POST-OPERATIVE TREATMENT

All the surgical operations were performed under anaesthesia. In the majority of cases a closed oxygen-ether narcosis was used, attended to by an anaesthetician. It was customary to administer physiological saline or glucose solution by intravenous drip infusion, but rarely blood.

CUP ARTHROPLASTY

In the first six cases of mold arthroplasty the SMITH-PETERSEN incision and corresponding operative technique were used. In one case the incision of GIBSON (1950) was employed. The following technique was used in all the other cases: The patient is laid on his sound side on an ordinary operating table. The part of the table which supports the lower extremities is lowered sufficiently to elevate the region of the greater trochanter. A posterolateral longitudinal incision is made over the greater trochanter. The fascia lata is divided and the part of the greater trochanter to which the gluteus medius and minimus are attached is separated with a chisel. The hip joint is dislocated by placing the thigh into adduction and external rotation. Should the piriformis and quadratus femoris muscles prevent dislocation of the joint they are detached near the trochanter. The joint capsule is resected over a fairly large area. The osteophyte collar of the femoral head is removed and the acetabulum is deepened and shaped if necessary.

REPLACEMENT ARTHROPLASTY

In endoprosthesis arthroplasties the technique described by the JUDET brothers was used for the insertion of the prosthesis. The femoral head was resected as sparingly as possible to prevent shortening of the femoral neck. In other respects the above described operative technique was employed.

SKIN ARTHROPLASTY

The skin arthroplasty technique devised by K. E. KALLIO has already been presented in an earlier publication (1956) and in a film which was shown in 1955 in France, Switzerland and China, in 1956 in Scandinavia and Poland, and in 1957 in the United States, Germany and Spain.

»*Technique.* — The patient lies on his side on an ordinary operating table, with the lower limbs hanging down to make the trochanteric region prominent. The skin is cleansed by means of alcohol and treated by iodine in the conventional manner. The skin of the lower part of the abdomen is left uncovered (fig. 2). The operation is carried out under general anaesthesia and antishock treatment by intravenous drip infusion.

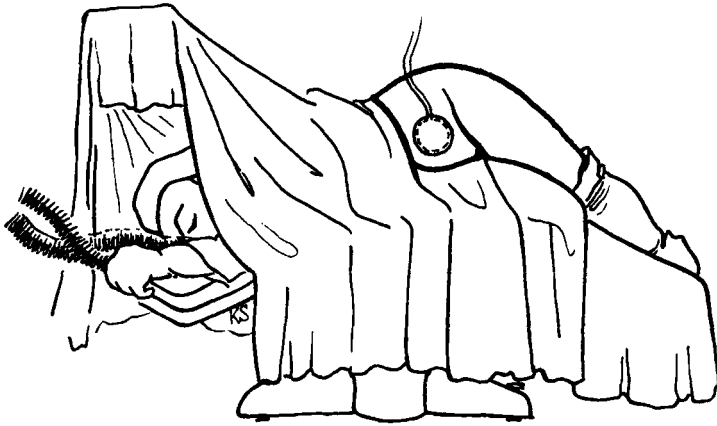


Fig. 2. — On the skin of the abdomen a small circle is visible, along which a steel wire has been passed through the skin. Note also the position of the patient on the operating table. (Courtesy of K. E. Kallio).

The operation is performed through a posterolateral approach on the lateral aspect of the trochanter, through the skin and fascia lata. The trochanter is temporarily detached. The head of the femur is dislocated and the capsule resected. Osteophytes on the head and neck of the femur are removed, but the shape of the articular surface of the head with the arthrotic, smooth, sclerotic weight-bearing area is left intact, to allow it to retain its natural form. The acetabulum, if intact, is not touched. Thus the joint surfaces of the head and the acetabulum fit each other in the natural way. The surface of the head, however, has been freshened by means of a file.

The interposition material is obtained from the skin of the abdomen.

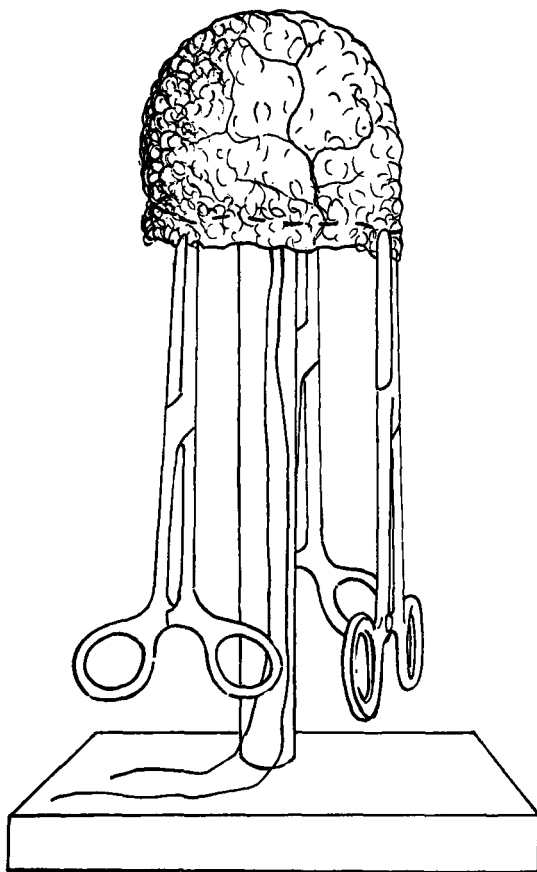


Fig. 3. — The round whole-thickness skin graft with fatty tissue has been placed upside down onto a block, on which it is stretched and moulded.
(Courtesy of K. E. Kallio).

A circle of about 8—9 cm. in diameter is drawn with the aid of a pair of compasses, and a steel wire is passed through the skin along the circle. At a distance of 0.5—1 cm. of it a circular incision is made, and the piece of whole skin with an appropriate layer of subcutaneous fatty tissue is detached. The margins of the skin defect are temporarily pressed together by means of pincers. The skin graft is stretched and shaped into a cap on a «hatblock», on which it has been placed with the subcutaneous fatty tissue upwards (fig. 3). A trial reposition is now done. After this, the skin cap is placed on the head of the femur and attached to it tightly by means of the steel wire which was passed through the skin flap along the circular line. The edges of

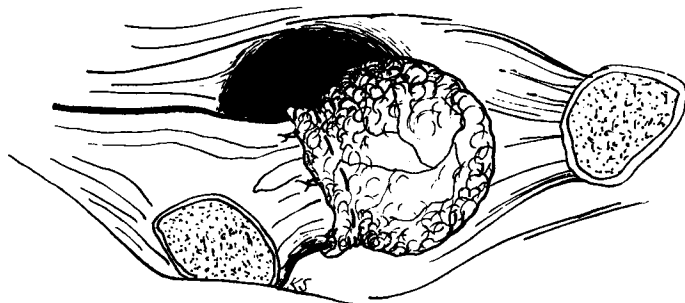


Fig. 4. — The finished skin cap has been placed on the head of the femur and tied to it with steel wire, the epidermis being against the freshened surface of the femoral head. (Courtesy of K. E. Kallio).

the skin flap are sutured with catgut to the remaining parts of the capsule. (Fig. 4)

The femur is now reduced and the trochanter is fixed to its place with a couple of steel wires. The incision is closed.»

The wire passed around the skin graft is visualised in the postoperative control roentgenogram and thus it is possible to check that the transplant has not shifted.

POSTOPERATIVE TREATMENT

The first six patients on whom a vitallium cup arthroplasty was performed were placed in a plaster hip spica. This was opened 2 weeks later and gentle exercise was started with the hip. One week later the cast was entirely removed.

In all the other cases of arthroplasty the limb was suspended without plaster from a Balkan beam and fastened by means of a Kirschner wire through the tibial tuberosity to a rope system which permitted movement of all the joints of the limb (fig. 5). The patient was urged to immediately start to move the ankle and the knee, but to begin movements of the hip joint 1 week later in the case of vitallium cup or endoprosthesis arthroplasties and 2 weeks later in the case of skin arthroplasties.

All the patients were given prophylactic antibiotic treatment for about 1 week after the operation.

In the vitallium cup and endoprosthesis arthroplasties the Kirschner wire was usually removed from the tibia 4 weeks after the operation. Patients on whom skin arthroplasty had been performed were kept on the Balkan

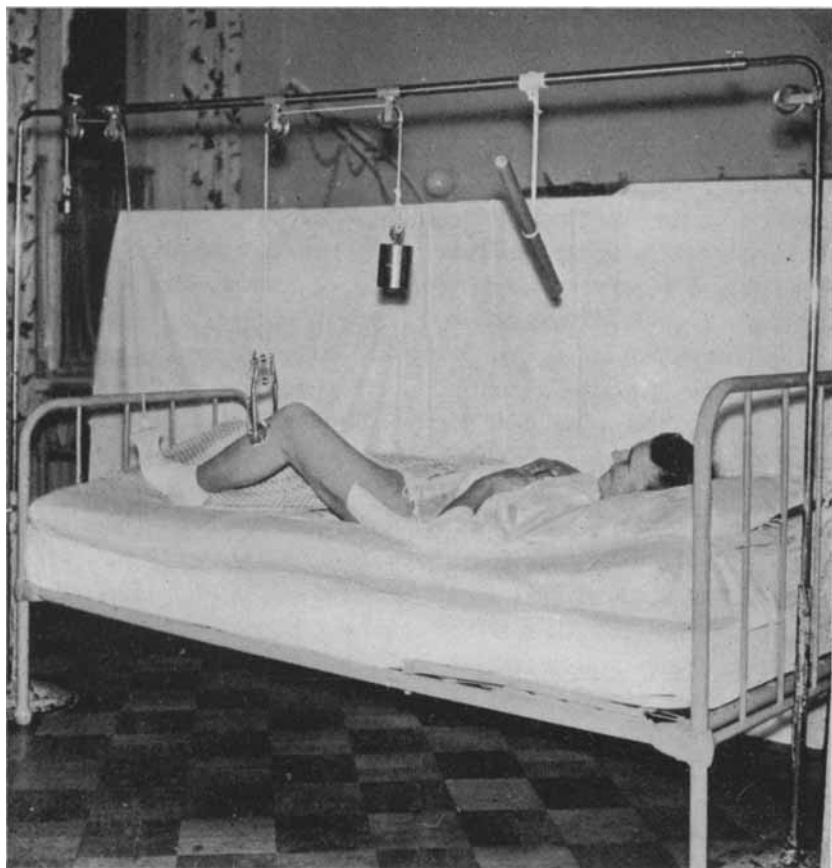


Fig. 5.

beam for 1 week longer. The patients were taught to walk without weight-bearing on the operated limb, first between parallel bars and then with crutches. This period of exercise lasted about 1 week in the hospital and was continued in the patient's home. He was told to use crutches for at least 4 months, at the end of which he was to return for a check-up. Nearly all the patients arrived for this examination. It was usually possible to discard the crutches at this time, but in some exceptional cases they were still retained for a time. In cases of skin arthroplasty in particular it was considered necessary to defer weight-bearing on the joint for a longer time. After discarding the crutches the patient used an ordinary cane. In the earlier cases

he was permitted to leave off the cane when he felt that his limb was stable. In later operations it has been considered advisable to continue to use the cane for a longer time, and since 1956 we have therefore urged all patients with arthroplasty to use it at least out of doors and on longer walks.

In the earlier cases the patients were recommended to exercise frequently the extension-flexion movement and to avoid positions requiring adduction. Abduction, on the other hand, was hardly encouraged before several months had passed from the operation. The purpose was to ensure ossification of the trochanter and to prevent the development of postoperative positive Trendelenburg's signs. This was generally successful, but, at the same time, abduction remained limited or was entirely absent. In the cases operated on later, the necessity of continuous abduction exercise was emphasised, but not before 4 months had passed from the operation (at present 6 weeks). Rotation exercises have also been urged. However, it has been necessary to leave the exercises for joint mobilisation and muscle strengthening chiefly to the patient's own activity, and it has not been possible to give instruction in physiotherapy as widely as would have been desired. Many patients have their homes beyond long and difficult distances and also for financial reasons seldom travel to Helsinki. When after a long interval of time they finally arrive for a follow-up examination, it often is found that exercise has unfortunately been neglected and contractures have developed.

VIII. POSTOPERATIVE COMPLICATIONS

»Postoperative complications» are in the present connection used to indicate such undesirable consequences arising from the operation as were diagnosed during the time of postoperative hospitalisation. This period was variable in length. Patients on whom vitallium cup arthroplasty had been performed were hospitalised after the operation for 27—66 days (average 42 days) including the day of operation and the day of discharge, patients with endoprosthesis 30—79 days (average 36 days), and those with skin arthroplasty 33—66 days (average 41 days). The complications during this period are shown in table 12. In 146 cases there was no complication, whereas 26 complications occurred in 25 cases (in a case of endoprosthesis arthroplasty, postoperative dislocation was associated with infection). One case of endoprosthesis ended fatally because of thromboembolism 3 weeks after operation. Since this was the only fatal case, the mortality rate was as low as 0.58 per cent. The incidence of thrombosis and thromboembolism was 9.9 per cent, which was practically the same as, for example, in the series of GADE (9.2 per cent) but definitely lower than in KARLEN's series of hip arthrodesis (22.1 per cent).

TABLE 12. — *Postoperative Complications*

Complication	Vitallium Cup	Endo-prosthesis	Skin Arthroplasty	Total
	Cases	Cases	Cases	Cases Per cent
Thrombosis and thrombo-embolism	5	9 ¹	3	17 = 9.9
Infection	1	3	0	4
Paresis of peroneal nerve ..	1	0	1	2
Subluxation	1	0	1	2
Dislocation	0	1	0	1
Total No. of complications	8 (22.8 %)	13 (15.6 %)	5 (9.4 %)	26 (15.2 %)

¹ 1 fatal case

No infections occurred in the skin arthroplasties. One of the two patients with paresis of the peroneal nerve was healed in 2 months. Permanent reposition was possible in both cases of subluxation. The dislocation in a case of endoprosthesis was also reduced but infection developed and a small fistula remained, which has been open occasionally. The cause of the dislocation was apparently a short femoral neck and valgus position of the endoprosthesis. Closure of the site from which the skin graft was taken caused no difficulty in any of the cases. Both silk and steel were used as suture material and the stitches were not removed before 2—3 weeks after the operation.

After a major operation of this size the risk of thrombosis and embolism is always a factor to be considered, as in surgery in general. With a view to prophylaxis of thrombosis we have always encouraged movements of the healthy limb and of all joints other than the operated hip joint, starting with the first postoperative days. No medical prophylaxis for thromboembolism has been used by us.

As has been observed, the least complications occurred in the skin arthroplasty group. At the time of submitting this report for printing, a total of 94 skin arthroplasties of the hip joint had been performed in our Clinic without occurrence of a single case of infection.

IX. FOLLOW-UP STUDIES AND RESULTS

The symptoms to which relief is sought by the arthroplasty operation are stiffness of the joint and pain. An objective evaluation of the results of the operation is attended with some difficulty, however. The change in the mobility of the joint can be measured, but this is not the case with the pain. As we well know, the capacity to feel and endure pain is greatly variable. The same is true of the patients' attitude towards pain. Hence the follow-up results depend to a very great extent upon the patients' reaction and are subjective.

From table 13 are seen the replies that the patients gave to the questionnaire. The pain had not disappeared from all the patients who stated that the condition of the hip joint was improved after the operation. Usually, however, the pain had abated to some extent or had not originally been very severe, but a troublesome deformity and stiffness of the hip joint were eased, since the patients reported improvement of the condition. The fact that relief from pain appears not to have been quite as good after the skin arthroplasty as after alloplastic arthroplasties may be due in part to technical reasons. The procedure in the performance of skin arthroplasty is not as radical as in alloplastic operations and after-treatment also was slightly different. In the endoprosthesis group it is notable that the pain had been absent from a larger proportion of the group than that from which the pain had disappeared. The difference is due to the cases of fracture of the femoral neck, which were immediately operated on and which consequently were not painful before occurrence of the fracture. All the groups appear to be in a similar position in respect to the severity of the pain persisting after the operation, judging from the fact that about 30 per cent of the patients in each group continued to use drugs. Crutches were used by a larger number of patients in the skin arthroplasty group than in the other groups, because we have urged them to do so, with the purpose that function and limited weight-bearing together would, with time, develop the best possible joint. We have done so especially in cases in which the mechanics of the joint were

TABLE 13. — *Follow-Up Data Obtained by Questionnaire*

	Vitallium Cup (34 Cases)	Endoprosthesis (75 Cases)	Skin Arthroplasty (52 Cases)
	Per Cent	Per Cent	Per Cent
Hip improved after arthroplasty	91	86	81
Pain disappeared or was definitely relieved postoperatively	83	82	67
Pain has remained completely or almost completely absent	65	87	62
Pain still present			
At rest	12	12	17
On beginning to walk	44	64	50
On walking	53	61	46
After walking	27	29	25
Analgesics still used	32	27	31
Present manner of walking			
Without cane	29	23	19
With cane	53	49	37
With crutches	6	7	23
Distance walked without stop- ping			
Less than 100 metres	16	30	25
" " 500 " 	35.5	20	27
" " 1000 " 	13	16	15
Over 1000 " 	35.5	34	33
Able to ride bicycle	35	43	37
Able to put on shoe and sock better	41	39	40
Joint feels natural (like patient's own joint)	44	60	81

unfavourable. Furthermore it is to be noted that the follow-up period has so far been shorter in the cases of skin arthroplasty than in the other groups of cases.

Bicycle riding calls for considerable activeness on the part of the patient and thus is not actually an indication of the condition of the hip joint. About 40 per cent of the patients in each group can now put on their shoes and socks more easily. This daily act which illustrates the practical mobility of the joint appears to have been aided approximately similarly by the different types of arthroplasty employed.

The question as to whether the new joint feels like a natural joint was answered in the affirmative by 81 per cent of the patients with skin arthro-

plasty, 44 per cent of those with cup arthroplasty, and 60 per cent of those with an endoprosthesis.

The patients had resumed their work on an average 6 months after the operation. The reply to the question of how soon after the operation work was started was specified in time units in 118 cases. Work had been begun on the average 5.9 months after operation by 55 patients with endoprosthesis, in 6.2 months by 37 patients with skin arthroplasty, and in 6.5 months by 26 patients with cup arthroplasty. Nearly all of them had returned to their previous occupation, with the exception of a few of the younger patients who had learned a new vocation and some of the older patients who had been pensioned.

The question as to how the operated hip had progressed with time was answered in the ways listed in table 14. The replies are encouraging for the

TABLE 14. — *Development during First Three Postoperative Years*

	Poorer	No Change	Better
<i>During first year after operation</i>			
Cup arthroplasty	18	6	10
Endoprosthesis arthroplasty	47	17	10
Skin arthroplasty	40	11	1
Total No. of cases	105	34	21
<i>During second year after operation</i>			
Cup arthroplasty	16	13	5
Endoprosthesis arthroplasty	24	17	33
Skin arthroplasty	7	5	3
Total No. of cases	47	35	41
<i>During third year after operation</i>			
Cup arthroplasty	7	7	2
Endoprosthesis arthroplasty	4	8	18
Total No. of cases	11	15	20

skin arthroplasty technique. A follow-up time of 1—2 years is, of course, a short one, but the difference is clearly evident between these replies and those given by the patients who had been treated by alloplastic methods. During the second year the difference appears to have levelled off, but the series is a small one.

The purpose of the question concerning the present condition of the opposite hip joint was to obtain information on the extent to which this joint possibly was overstrained after the arthroplasty. The replies revealed that

healthy hips had not become painful, but hips which already previously had been diseased were to some extent affected by this additional stress. If we review the cases in which the opposite hip joint was now stated to be poor or poorer than previously we will obtain the following figures: Mold arthroplasty, 5 cases; endoprosthesis, 8 cases; skin arthroplasty, 4 cases. Trendelenburg's sign was positive in a total of 10 cases, which is equivalent to about 6 per cent of the total series. By not permitting weight-bearing on the operated hip before 3—4 months had passed from the operation an opportunity was given to the detached greater trochanter to undergo reliable consolidation. This evidently explains why Trendelenburg's sign was rarely seen.

The comparison of the follow-up roentgenograms with those made earlier revealed the following findings. In the cases of skin arthroplasty the joint space had gradually become more distinct in about every fifth case. Since it was not distinct in the first postoperative roentgenogram but was so about one year later, it seems probable that new tissue had gradually developed and replaced the interposed skin. Hence this is the result of a relatively lengthy development. In all cases of this kind the patient also was satisfied with the result. Since it has not been possible to take biopsy specimens we are not in a position to prove the nature of the translucent tissue which in the roentgenograms is seen to have developed between the bony surfaces of the joint. KETTUNEN (1958) showed in animal experiments that the skin graft was replaced by cartilage and he regarded it as certain that the cartilage is the result of metaplasia of the interposed connective tissue. It may be presumed that the same development also occurs in favourable cases after arthroplasty performed on man¹.

The femoral neck appeared to have worn down in length in 10 cases of skin arthroplasty and 9 cases of vitallium cup arthroplasty. We have not found new osteophyte formation at the head of the femur after skin arthroplasty. LOEFFLER (1956) has made a similar observation. In mold and endoprosthesis arthroplasties, on the other hand, osteophytes were frequently found to have developed.

In mold arthroplasties the position of the cup was found to have changed in one case only. Evidently the head of the femur moves within the cup but the cup usually remains firm in the acetabulum. The endoprosthesis had shifted in about every fourth case. It had originally been placed in the

¹ In fact, we have had an opportunity quite recently to re-open a knee joint about 6 months after skin arthroplasty and the changes seen in the biopsy specimen were similar to those demonstrated in the animal experiments.

varus position in 17 cases, but the prostheses in this position were not found to have shifted more frequently than those in the normal position. The femoral neck appeared to have become longer because of the endoprosthesis in 20 cases and in these cases the result was better than the average. This would seem natural from the standpoint of mechanics of the joint.

It was a general observation that a roentgenogram that appeared unfavourable did not necessarily mean that the arthroplasty was unsuccessful.

To obtain data on the changes in the mobility of the hip joints I calculated GADE's mobility index figures and the means of these index figures for each group from all the available data on mobility and after follow-up periods of various lengths. The results are shown in table 15 and fig. 6. *

TABLE 15. — *Changes in the Mobility Index of the Hip Joint*

Time of Measurement	Vitallium Cup		Endo-prosthesis		Skin Arthroplasty		Total	
	Index	Cases	Index	Cases	Index	Cases	Index	Cases
Before operation	20.3	(34)	18.3	(74)	26.3	(53)	21.3	(161)
3- 4 months after operation	43.0	(28)	44.2	(59)	51.0	(39)	46.1	(126)
12-23 » » »	45.7	(17)	46.7	(25)	52.0	(46)	49.6	(88)
24-35 » » »	50.1	(15)	45.6	(29)	45.7	(8)	46.9	(52)
36-47 » » »	40.1	(7)	47.8	(34)	—	—	46.5	(41)
48 » or more after operation	47.5	(6)	45.3	(20)	—	—	45.8	(26)

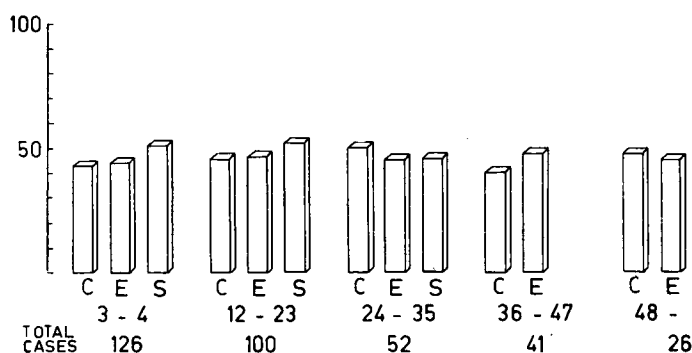


Fig. 6. — Dependence of the attained range of mobility on the length of the observation period. Ordinate: Mobility index, abscissa: Months after operation.

* In figures 6, 7, 8 and 10: $\begin{cases} \text{C} = \text{Cup arthroplasty} \\ \text{E} = \text{Endoprosthesis arthroplasty} \\ \text{S} = \text{Skin arthroplasty} \end{cases}$

In reviewing separately the 88 cases in which the follow-up time was 12—23 months we find that in 79 cases the mobility had increased and in 9 cases decreased, compared to the preoperative mobility index value. The mean mobility index for these 9 cases before operation was 45.1 and 12—23 months later 30.0. These cases comprised 2 cup arthroplasties, 4 endoprostheses and 3 skin arthroplasties. The mean index figure for the 79 cases in which the mobility increased after the operation was before operation 19.9 and 12—23 months later 51.5. The figures for the different operations were as follows: Cup arthroplasty, initial value 19.6, later value 50.2, an increase of about 160 per cent; endoprosthesis arthroplasty, initial value 17.2, later value 52.0, increase about 200 per cent; skin arthroplasty, initial value 24.0, later value 52.1, increase about 120 per cent. It is to be taken into consideration that the index values for skin arthroplasty were calculated from a larger series of cases than the cup and endoprosthesis arthroplasties together.

The index values are relative figures which naturally permit the drawing of few conclusions only. At the follow-up examination the patients frequently stated that the condition of their hips was greatly variable, attributing this to weather conditions, amount of stress, and even to psychic vacillations. In any case, the patient assured that the mobility of his hip joint was sometimes better, sometimes poorer. The same factors, nevertheless, applied to the entire series of patients and thus do not reflect unfavourably on any of the different types of arthroplasty. Furthermore, in the greater part of the series the mobility of the joints was measured a number of times at intervals of varying length, and the mean values are therefore hardly influenced by incidental factors. It is interesting to note how the length of the follow-up period had an effect on the mobility of the joint. This is shown by table 15 and fig. 6. It is observed that the range of motion which the joint had attained during the actual exercising period remained approximately unchanged for years. There are, of course, cases in which the mobility decreased with time. This occurred where the patient had not continuously exercised the joint. Cases were also seen in which the mobility of the hip joint had increased progressively. However, in the light of the mean values for the total series of cases the situation had remained practically unchanged in this respect.

Let us now consider how the preoperative mobility of the joint influenced that attained later (fig. 7). It is astonishing to note that the latter was approximately equal in all cases regardless of the degree of preoperative stiffness. On the basis of the mean values for the total series we find that the

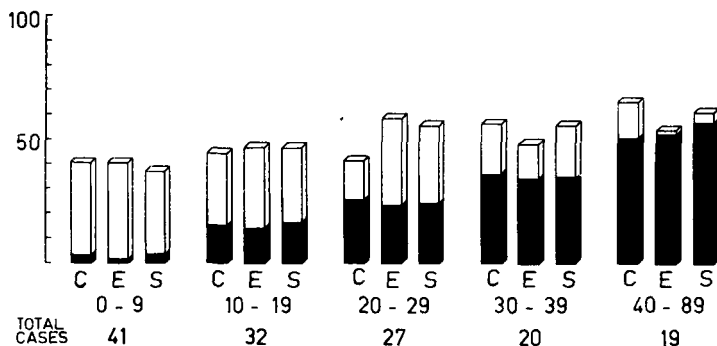


Fig. 7. — Dependence of the attained range of mobility on the preoperative range. Black portion of column indicates the mean mobility index before operation. Ordinate: Mobility index 7—1 year after operation, abscissa: Mobility index before operation.

mobility was about doubled. However, if we compare the final values with the initial values in the different stiffness groups we will observe that joints which originally were quite stiff had become nearly as movable as joints which initially showed relatively good motion, and that the latter, for their part, had not increased in mobility to any noteworthy extent. A factor which has some bearing upon this is, in my opinion, the fact that the patients generally do not place greater demands upon the mobility of the hip. The full normal mobility of the hip joint is ordinarily not required in daily life, and the exercising of an operated hip joint usually takes place only within the requirements of daily use.

We shall now discuss the statements made by the patients themselves concerning the result of the operation and the correlation of these statements to certain circumstances. In drafting the questionnaire I gave the alternatives of «very satisfied», «satisfied», «cannot say», and «dissatisfied». By grouping together the definitely favourable evaluations — very satisfied and satisfied — and comparing them with the total number of replies we obtain the results in fig. 8. We observe that independently of the type of arthroplasty about two-thirds of the patients were satisfied with the result of the operation.

The correlation of this feeling of satisfaction to the diagnosis is shown in fig. 8 in the cases with primary and secondary osteoarthritis, and in table 16 in the cases with other diagnoses.

In the group of primary or essential osteoarthritis, endoprosthesis arthroplasty appears to have given the best satisfaction, while in the secondary

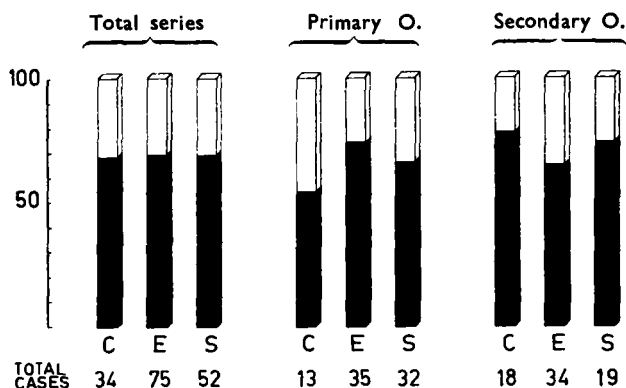


Fig. 8. — Patients' opinion on the result of the operation in the total series and in the primary and secondary osteoarthritis groups. Black portion of column indicates a definitely favourable opinion.

TABLE 16. — *Patients' Opinion on Result of Operation in other Groups*

Diagnosis	Vitallium Cup	Endo-prosthesis	Skin Arthroplasty	Total
	Cases	Cases	Cases	Cases
Tuberculosis	2/3	1/1	1/1	4/5
Fracture of femoral neck	—	3/4	—	3/4
Condition after arthroplasty	—	0/1	—	0/1
Ochronosis	0/1	—	—	0/1

First figure = Patient's opinion: «Satisfied»

Second figure = Total number of patients who replied to questionnaire

osteoarthritis group the cup arthroplasty was considered best. Skin arthroplasty was given an intermediary rating in both groups.

The situation in the subgroups of secondary osteoarthritis is reviewed in table 17. Cup arthroplasty evidently gave the best result in dysplasia. Nearly all the patients with rheumatoid arthritis were satisfied with their operation independent of the method. In secondary osteoarthritis developing on the base of trauma the arthroplasty appears to have been of benefit irrespective of the type.

In the light of the total series the evaluations by the patients were distributed as shown in table 18 and fig. 8.

As we have observed, the different operative techniques gave, on the whole, similar results. The increase in mobility was approximately the same, and the same proportion of patients in each group was satisfied with the

TABLE 17. — *Patients' Opinion on Result of Operation in Sec. O. Group*

Diagnosis	Vitallium Cup	Endo-prosthesis	Skin Arthroplasty	Total
	Cases	Cases	Cases	Cases
Dysplasia	8/10	2/4	4/7	14/21
Rheumatoid Arthritis	1/1	11/11	6/7	18/19
Coxa vara adultum	0/1	4/9	1/1	5/11
Trauma	4/5	3/5	1/1	8/11
Protrusion of acetabulum ..	—	1/2	1/1	2/3
Non-rheumatic arthritis ..	1/1	0/2	0/1	1/4
Spondylarthritis ancylopoetia	—	1/1	—	1/1
Coxa plana	—	—	1/1	1/1
Total No. of cases	14/18	22/34	14/19	50/71

First figure = Patients' opinion «Satisfied»

Second figure = Total number of patients who replied to questionnaire

TABLE 18. — *Patients' Opinion of the Result of Operation in the total Series*

	Vitallium Cup (34 Cases)	Endoprosthesis (75 Cases)	Skin Arthroplasty (52 Cases)	Total (161 Cases)
	Per Cent	Per Cent	Per Cent	Per Cent
Very satisfied	21	36	19	27
Satisfied	47	33	50	41
Cannot say	23	23	27	25
Dissatisfied.....	9	8	4	7
Total	100	100	100	100

end result. In respect to disappearance of pain, skin arthroplasty appears to have given slightly poorer results, but the difference is not very significant. It may be considered possible that adhesions which give rise to pain may more readily develop in skin arthroplasty. Since, furthermore, the hip joints in these cases were immobilised for a longer time than in the other groups, the cause of pain in a greater proportion of patients might be a postoperative haematoma with consequent adhesions.

It is interesting to note how the patients' feeling of satisfaction was correlated to the degree of initial stiffness of the hip joint and to the disappearance or alleviation of pain. The total series of cases is reviewed together without regard to the type of arthroplasty in fig. 9.

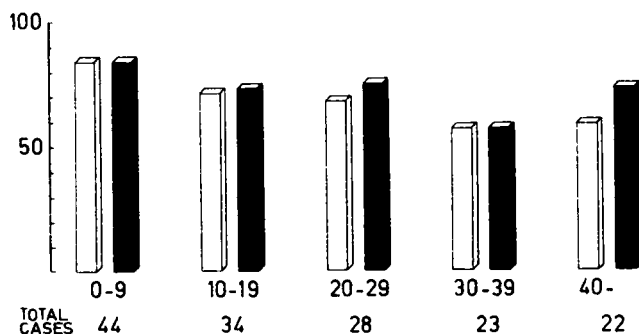


Fig. 9. — Correlation of the attained range of mobility and relief from pain to the pre-operative range of mobility. White column = Patients satisfied or very satisfied. Black column = Disappearance or definite alleviation of pain. Ordinate: Per cents, abscissa: Mobility index before operation.

Having observed above that the mobility attained was approximately of an equal degree in all the groups (cf. table 15 and fig. 6), we now find that the patients were the more satisfied with the result of the operation the stiffer the joint was before arthroplasty. The pain also appears to have been best relieved in these cases. In the group with the greatest initial mobility, a certain proportion of patients were not satisfied although the pain was relieved. Evidently the original condition had not been so poor that the benefit attained would have seemed significant. We further observe that the pain was least relieved in the group in which the initial range of mobility of the hip joint was indicated by the index figures 30 to 39. What could have been the reason for this? Possibly osteoarthritis is most painful at the time that the mobility is within this range, or was the poorer result due to certain coincidences?

The opinion of the patient can probably not be regarded as an adequate criterion, and not always even a correct one, considering the evaluation of the case as a whole. I have therefore compiled a series of criteria of another kind to serve as basis for another comparison. The patient's opinion is also taken into consideration in doing so, but two additional features are included, *i.e.*, relief of pain and increased mobility. For evaluation of the former we must depend upon the patient's own statement, but the latter has been measured with the goniometre.

Patient's opinion:	Very satisfied	3 points
	Satisfied	2 »
	Cannot say	1 »
	Dissatisfied	0 »
Relief of pain:	Pain now absent	3 »
	Pain relieved	2 »
	Pain unchanged	0 »
Increase of motion (mobility index):	Increase 200% or more	3 »
	» 100—199%	2 »
	» 20—99%	1 »
	» less than 20%	0 »
Rating: 8—9 points Excellent		
6—7 » Good		
4—5 » Fair		
0—3 » Poor.		

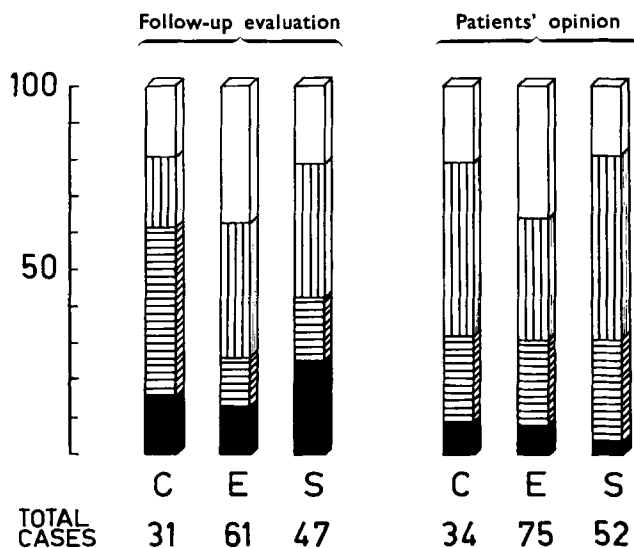


Fig. 10. — Comparison of the follow-up evaluation and the patients' opinion of the result. White column = Excellent — very satisfied. Vertically shaded column = Good — satisfied. Horizontally shaded column = Fair — cannot say. Black column = Poor — dissatisfied.

On comparing the points so obtained with the replies given by the patients (fig. 10) we observe that the cases which received the highest rating (excellent) corresponded well with those in which the patient was very much satisfied with the result. A part of the cases in which the patient could express no opinion were poor according to the points calculation. Many patients were satisfied where my calculation gave only a fair rating.

In the light of the tables the vitallium cup and skin arthroplasties would seem to be of approximately equal value and the endoprosthesis arthroplasty slightly more satisfactory. This, however, need not mean that endoprosthesis would probably be preferable to the two other techniques. The opinion is gained from the literature that the Judet type of hip arthroplasty is gradually being taken with increasing reservation, for complications, such as loosening and breakage of the endoprosthesis, have not been infrequent. In the present series, also, two endoprostheses had to be removed, although not because of breakage. In one of the cases (incidentally, the first case in our series) there was a refractory infection, and in the other case the pain was of such severity that removal of the prosthesis was considered to be indicated. It appears probable that we will find it necessary to remove a few more endoprostheses before long. The question arises as to what should be done in such cases. GUILLEMINET and MARION (1955) have discussed this question in a comprehensive paper. They presented the following four alternatives: Removal of the prosthesis, with no further procedures; replacement of the old prosthesis by a new one of possibly another type; arthrodesis; various kinds of osteotomies.

One is not tempted to insert a new prosthesis, for it also may work loose or break. An arthrodesis may possibly be unsuccessful. An osteotomy would in these cases shorten the limb further. In their conclusions GUILLEMINET and MARION reverted to the choice of arthrodesis and osteotomy in the majority of cases of hip trouble and reserved the arthroplasties for rare, well selected cases. They have not entirely discarded endoprosthesis arthroplasty but they have gone over to a prosthesis of a new type.

According to studies made by SHEPHERD, among others, the prognosis of vitallium cup arthroplasty does not appear to be as indefinite as that of endoprosthesis arthroplasty. In a few well selected cases the method is continuing to be employed also in our Clinic. Our knowledge concerning skin arthroplasty is still deficient and the follow-up period is short. However, the conclusion may already be drawn that skin arthroplasty is not, at least, threatened by all of the same late complications as alloplastic arthroplasties are.

A number of other circumstances should still be considered in order to obtain a more complete picture of the condition of the patients and of the value of the arthroplasty operation. Such features are the patient's gait and ability to walk, stability of the joint, the power of the muscles which move the joint, and the true working capacity of the patients before and after the operation. In an evaluation of the end result there should further be considered the probable condition of the hip joint had not the operation been performed.

The results of arthroplasty reported in the literature diverge greatly indeed. The criteria used by the different investigators are not uniform, but if we take into consideration only the results which are stated to have been favourable we will obtain the following list:

	Favourable Results %	Total Number of Cases
GADE (1947)	67	54
DEBEYRE and DOLIVEUX (1954)	40	178
SHEPHERD (1954)	40	642
GUILLEMINET and JUDET (1955)	67	789
MERLE d'AUBIGNÉ and MAURER (1956) ..	64	109
MERLE d'AUBIGNÉ and POSTEL (1956) ..	50	57
RAMADIER and LEVITAN (1956)	59	117
AUFRANC (1957).....	82	1000
Present series	69	161

On the basis of this list it may be stated that the results obtained in our series of cases correspond well with those presented in the literature.

X. CERTAIN CASE REPORTS WITH ROENTGENOGRAMS

Vitallium Cup Arthroplasty

Case C—1. — A 47-year-old hospital fireman — the first patient in our series of cup arthroplasties — had a history of pain in the hip on exertion of 4 years' duration. The hip joint showed extension-flexion of 180° — 120° , adduction of 30° , and external rotation of 15° ; other movements were absent. The mobility index was 43. Dg.: Arthrosis deformans primaria coxae. Unfortunately a preoperative roentgenogram was not available.

The roentgenogram in fig. 11, made nearly 7 years after operation, showed practically complete absence of the femoral neck and a rather unfavourable inclination of the cup. The stump was in a position of subluxation and the osteophytic ridge at the rim of the acetabulum apparently was necessary to prevent dislocation of the joint. The range of motion was now: Extension-flexion, 175° — 90° ; abduction, 10° ; adduction, 25° ; internal rotation, 5° ; external rotation, 10° . The mobility index was 57. The patient had walked for many years without a cane and was able to ride a bicycle well. He stated that the pain had completely disappeared and that he was very much satisfied with the result. Follow-up rating: Good.



Fig. 11.

Case C—17. — A labourer, 25 years of age, had had pain in the hip as far back as he could remember. The pain was present both on exertion and at rest, but the use of analgesics had been necessary for about 1 year only. For 2 months he had been fully incapable of work. Resection of the obturator nerve had been performed 3 months previously, with no benefit. Range of motion of the hip joint: Extension-flexion, 180° — 90° ; adduction, 20° ; other movements absent. The patient walked with short steps and a limp. Trendelenburg's sign was positive. The mobility index was 49. Dg. Arthrosis deformans secundaria coxae. Dysplasia acetabuli et subluxatio coxae. (Fig. 12.)

The roentgenogram in fig. 13 was made nearly 3 years after cup arthroplasty. The cup was seated fairly securely in the acetabulum. The weight-bearing area of the femoral head was now more favourable than earlier and the position of subluxation was clearly better after improvement of the shape of the acetabulum. The range of motion was now: Extension-flexion, 180° — 90° ; abduction, 15° ; adduction, 30° ; internal rotation, 15° ; external rotation, 25° . The mobility index was 70. There was no actual pain, but some tenderness on movement was present. Patient's opinion: Satisfied. Follow-up evaluation: Fair.



Fig. 12.



Fig. 13.

Case C—18. — A business manager, aged 64, had a history of distress in the hip of 30 years' duration. Pain was continuously present, especially on movement and after stress, but also at rest, disturbing sleep. He had used drugs for about 20 years and received roentgen therapy occasionally during the past 10 years. For 13 years he had used a cane. Motion in the hip was limited to a painful jerk. The joint was ankylosed in a position of 150° flexion and 15° adduction. The mobility index accordingly was 0. Dg Arthrosis deformans secundaria cosae Anchylosis coxae. Dysplasia acetabuli et subluxatio coxae. (Fig. 14.)

Fig. 15, made 2 weeks after vitallium cup arthroplasty, shows that the osteophyte formation on the rim of the acetabulum was retained. In fig. 16, 2½ years after operation, the position was unaltered and the femoral neck did not seem shorter; osteophyte formation had not increased. Pain had disappeared completely and Trendelenburg's sign was negative. Motion of the hip: Extension-flexion, 180°—130°; abduction, 5°; adduction, 25°; internal and external rotation, each 5°. The mobility index was 35. The continued use of a cane was recommended. Patient's opinion of the result: Very satisfied. Follow-up evaluation: Excellent.



Fig. 14.



Fig. 15.



Endoprosthesis Arthroplasty

Case E—13. — A 58-year-old office clerk, male, had had left hip trouble since the age of 17. There had been constant pain but he had used hardly any drugs and had been able to work without interruption. The hip had a slight adduction and external rotation deformity. Movements: Extension-flexion, 170° — 105° ; other movements, 0; mobility index, 33. Dg. Coxa vara adultum arthroticum.

Following the performance of endoprosthesis arthroplasty the pain was absent, with the exception of insignificant tenderness in connection with heavy stress. Over 4 years after operation the range of motion was: Extension-flexion, 175° — 120° ; adduction, 25° ; internal rotation, 10° ; external rotation, 20° ; abduction absent. The mobility index was 43. Trendelenburg's sign was negative. He used a cane and walked with a very slight limp.

Fig. 17 was made before operation and fig. 18 over 4 years later. The endoprosthesis was in a good position and had not shifted. The typical clarified area was seen around the shaft. Marked osteophyte formation was present. Patient's opinion: Very satisfied. Follow-up evaluation: Good.



Fig. 17.



Fig. 18.

Case E—14. — A labourer's wife, aged 47, had had hip pain during 10 years, of such severity as to disturb her sleep and she had used analgesics occasionally. Lately she had been unable to do her household work. The hip had a slight adduction and external rotation deformity. Extension-flexion was 150° — 130° ; no other movements were present. The mobility index was 12. Dg. Arthrosis deformans primaria coxae. Resection of the obturator nerve had been performed 6 years previously, relieving the pain for about 2 years. (Fig. 19.)

Fig. 20, made 2 weeks after arthroplasty, shows the endoprosthesis is in a varus position. In fig. 21, over 5 years after operation, the position of the prosthesis was unchanged and it seemed to be firmly seated. The clarified area did not appear to have increased. There was osteophyte formation. Pain had disappeared for about 2 years after operation and had then recurred in a milder form. Over 5 years after operation, motion of the hip was: Extension-flexion, 165° — 105° ; adduction, 20° ; other movements, 0. There was a slight external rotation deformity. Mobility index was now 34. Trendelenburg's sign was negative. The patient stated that she had a sensation of something strange in the hip but it hardly caused any trouble. Patient's opinion: Satisfied. Follow-up evaluation: Good.



Fig. 19.



Fig. 20.

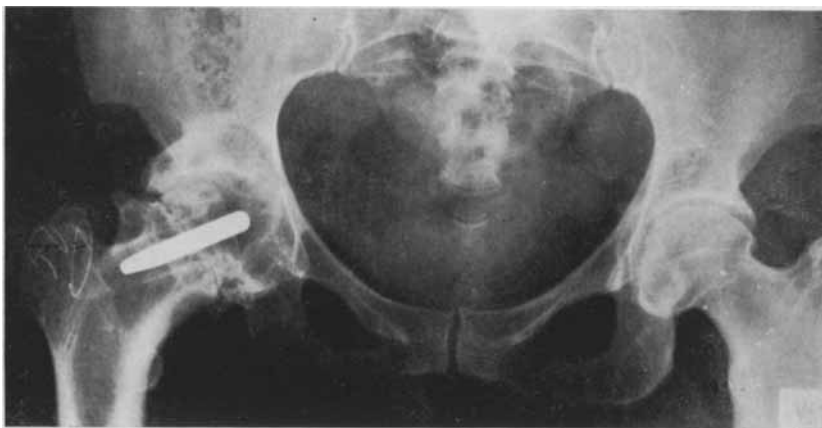


Fig. 21.

Case E—25. — A woman aged 66, widow, sustained a fracture of the femoral neck. An endoprosthesis was inserted 10 days after the accident. Fig. 22 shows the situation 4 years later. There was shifting of the prosthesis, which now apparently was loose and was pressed into a varus position. At least the shaft of chromium steel appeared to be intact. The patient was able to walk briskly, using a cane. There was no pain at rest and some pain on exertion, but drugs were not necessary. The range of motion was: Extension-flexion, 175° — 100° ; adduction, 20° ; internal and external rotation, 10° ; no abduction. Trendelenburg's sign was positive. The distance from the superior anterior iliac spine to the medial malleolus was 4 cm shorter.

This case should in my opinion be rated as poor, but surprisingly the patient stated that she is very much satisfied.



Fig. 22.

Case E—80. — A bank clerk, 37 years of age, complained of pain in the hip of 7 years' duration. The pain had occurred during and after stress and she had used drugs for 3—4 years. Range of motion of the hip joint was: Extension-flexion, 150°—100°; no other motion present. Mobility index: 23. Dg. Arthrosis deformans primaria coxae. (Fig. 23.)

Fig. 24 shows the situation over 2 years after endoprosthesis arthroplasty. Pain was present only after heavy stress. The patient weighed 93 kg. She was able to walk without a cane and did not limp. Range of motion: Extension-flexion, 180°—90°; abduction, 15°; adduction, 20°; external rotation, 20°; no internal rotation. The mobility index was, 64. Trendelenburg's sign was negative. The prosthesis was in a good position and appeared to be stable. The femoral neck seemed to have increased in length, which would be favourable. Patient's opinion: Very satisfied. Follow-up evaluation: Excellent.



Fig. 23.



Fig. 24.

Skin Arthroplasty

Case S—4 and S—22. — A farmer, 55 years of age, had skin arthroplasty performed on both hip joints at an interval of 8 months. Before the operations, pain had persisted for 20 years in the left hip, the one first operated on, and for 10 years in the other hip, and had been felt both on stress and at rest. The patient had used drugs for 17 years in the former case and during 10 years in the latter case. He stated he had, on an average, taken 3 powders daily during 10 years and that it had been difficult for him to do any kind of farm work. Range of movement on the left: Extension-flexion, 135° — 100° ; no other movements present; mobility index, 14. Motion on the right: Extension-flexion, 170° — 145° ; abduction, 5° ; adduction, 5° ; other movements, 0; mobility index, 19. Dg. Arthrosis deformans primaria coxae l.a.

Fig. 25 shows the condition before the first operation and fig. 26 that 4 weeks later. Fig. 27 was made 2 years after skin arthroplasty of the left hip (V) and 1 year 4 months after operation of the right hip. A distinct joint space had developed on the left side and the shape of the joint appeared natural. The right joint did not seem as favourable. The mobility index of the left hip was now 34 (extension-flexion, 165° — 125° ; abduction, 10° ; adduction, 15° ; external rotation, 10° ; internal rotation, 0). The mobility index of the right hip was now 40 (extension-flexion, 175° — 125° ; abduction, 10° ; adduction, 10° ; external rotation, 15° ; internal rotation, 0). Post-operatively there had been no pain on the left, and on the right only when starting to walk. The patient had needed no drugs and was satisfied with the condition of both hips; the left hip joint had been better than the right all the time. Follow-up evaluation of both hips: Good.



Fig. 25.



Fig. 26.



Fig. 27.

Case S—11 and S—46. — A small-holder's wife, aged 61 years, had skin arthroplasty performed on both hip joints at an interval of 1 year 3 months. Previously there had been constant pain in the left hip for 10 years and in the right hip for 6 years, disturbing her sleep. She had used analgesics for many years. The mobility index was 3 on the left and 16 on the right. Motion of the left hip was: Extension-flexion, 140° — 135° ; other motion 0; and of the right hip: Extension-flexion, 140° — 120° ; abduction, 5° ; adduction, 5° ; external rotation, 10° ; no internal rotation. Walking was difficult, very short steps only being possible; the limbs were in moderate external rotation.

Fig. 28 was made before operation and fig. 29 $1\frac{1}{2}$ years after the left arthroplasty and 3 months after that on the right. Figs. 30 and 31 were taken on the same occasion in the Lauenstein position (V = left, O = right). The joint spaces appear more distinct, especially on the left. After operation the pain had disappeared from the left but not from the right hip. The patient was very satisfied with the left hip but could not say anything definite about the right. The mobility index on the left increased to 27 (extension-flexion 165° — 125° ; adduction, 20° ; external rotation, 5° ; no other motion present). Information on movements of the right hip is not available for an observation period of over 1 year. Follow-up evaluation of the left hip joint: Excellent.



Fig. 28.



Fig. 29.



Fig. 30.

Fig. 31.

Case S—16. — A waitress, aged 58 years, had had pain in the left hip also at rest for 7 years, during which she had been incapable of doing her usual work. The left hip had gradually become nearly ankylosed, with a mobility index of only 3, corresponding to extension-flexion of 180° — 175° , all other movement being absent. Sitting was difficult.

Fig. 32 shows the condition before operation and fig. 33 2 weeks later. In fig. 34, made nearly $1\frac{1}{2}$ years later, the femoral head was worn down. The patient used crutches, mainly because of painful knees, but the hip pain also persisted. She was now able to sit comfortably. The mobility index was 73, corresponding to: Extension-flexion, 180° — 80° ; abduction, 15° ; adduction, 20° ; external rotation, 80° ; no internal rotation. The patient was satisfied with the result of the operation. Follow-up evaluation: Fair.



Fig. 32.



Fig. 33.



Fig. 34.

Case S—24. A shop manager, female, 31 years of age, had a history of pain in the right hip joint, also at rest, of 4 years' duration. She had used analgesics and for the past 8 months had been incapable of work. The limb was ankylosed in 45° external rotation and a slight abduction contracture, giving it 3 cm greater practical length. The only hip movement was extension-flexion of 180° — 135° . The mobility index was 27. Dg. Arthrosis deformans primaria coxae dx. (Fig. 35.) Two years before onset of the hip pain the patient had been a member of a selected amateur gymnastic team.

Fig. 36, made nearly 2 years after operation, shows correction of the extreme external rotation. A narrow joint space was visible. The weight-bearing area of the joint appeared fairly large, which was indeed necessary since she weighed 78 kg. There had been no pain since the operation and the mobility index had risen to 64. Motions were now: Extension-flexion, 180° — 80° ; abduction, 10° ; adduction, 30° ; external rotation, 20° ; no internal rotation.

The patient was satisfied with the result. The follow-up evaluation was: Good.



Fig. 35.



Fig. 36.

Case S—53. — A farmer's wife aged 41 had had continuous pain in the hip for 2 years both on stress and at rest. During the past 6 months there had been similar pain in the right hip, but of a milder degree. Movements were: Extension-flexion, 160°—105°; adduction, 20°; other movements 0. The mobility index was 31. Dg. Arthrosis deformans secundaria coxae l.a. Protrusio acetabuli l.a. (Fig. 37.)

Fig. 38 shows the situation 1 year after operation. There was no pain whatsoever at rest but some pain on stress. The mobility index was now 60. Movements: Extension-flexion 175°—65°; abduction, 10°; adduction, 40°; external rotation, 5°; internal rotation 0. She walked without a limp, using no cane. There was roentgenographic evidence also in this case of a clearer joint space.

In this single case it was found at operation that the cartilagenous surface of the femoral head was practically normal and it was left intact. The surface of the acetabulum was freshened and the skin cap was placed with the epidermal side against the acetabulum.

The patient was very satisfied with the operation. Follow-up evaluation: Good.



Fig. 37.



Fig. 38.

XI. DISCUSSION AND CONCLUSIONS

In evaluating the results of hip arthroplasty we must hold in mind what in general can be expected of such an operation. It may probably be regarded as self-evident that the treatment is more or less palliative. Arthroplasty always calls for opening and dislocation of the joint, which unavoidably disturbs the blood supply of the femoral head. In attempting to reconstruct a diseased joint it is most natural to endeavour to use the building materials of the organism itself. This would give at least a theoretic possibility of favourable functional metaplasia which may create a joint resembling a normal one. In order that this may take place, the conditions should, of course, be as favourable as possible. The structure of the joint should fill the static and mechanical requirements placed upon it and the disease process should not continue. By removing osteophytes we cannot remove osteoarthritis.

Hip arthroplasty has been subjected to considerable criticism. This is readily understandable. It seems indeed that some orthopaedic surgeons have assumed a negative attitude towards hip arthroplasty. Unsatisfactory results give no encouragement to continue to perform this operation, but good results do also exist. Should the operation have been refrained from in such cases also? Arthroplasty demands, above all, good judgment of the surgeon. Even when the indications are correctly chosen and the operation well performed technically, this does not ensure an excellent end result. The correct selection of patients, knowledge of the statics and mechanics of the joint, and attentive after-treatment are also factors of primary importance.

In the light of the present series of operated cases the various types of hip arthroplasty used do not appear to differ greatly with respect to the findings made at the follow-up examination. The observation period in the cases of skin arthroplasty was rather short, being 1 to 2 years only, whereas for the vitallium cup and endoprosthesis methods it was, on the average, about

two years longer. However, it was observed that the results of hip arthroplasty did not in general change to any appreciable extent after the first follow-up year. A comparison of the results obtained with the different methods of arthroplasty may therefore be justified despite the varying observation periods.

With respect to pain, the results of skin arthroplasty seem to be slightly poorer than those obtained with the other methods. It appears probable, however, that by further developing the operative technique and after-treatment it will be possible to improve the results also in this respect. It is evidently preferable to fix the skin flap firmly to the femoral head. Exercising of the joint would be started soon after the operation. Movements of the joint would possibly be facilitated if a large amount of subcutaneous fatty tissue were left on the skin graft. It may be presumed that skin arthroplasty requires lengthier and more careful aftertreatment than the alloplastic methods. If we regard it as possible that the skin is replaced by cartilagenous tissue due to function, as has been demonstrated in animal experiments (KETTUNEN), it is understandable that this requires a relatively long time. In those of our cases of skin arthroplasty in which the joint space was seen to have become clearer, several months had been required for this. A correctly planned course of aftertreatment is undoubtedly of great importance. Muscle exercises and movement of the joint should probably be begun early, but weight-bearing should not be permitted until at a relatively late date and it should be increased gradually. These points were taken into consideration in later skin arthroplasty operations of the hip, which are not included in the present series.

The present investigation may be considered to have given the following answers to the questions presented earlier in this report:

1. To what extent has it been possible to relieve the patient's pain by the different types of arthroplasty referred to in the foregoing?

After a follow-up period of 1 to 7 years the pain had disappeared or was definitely relieved in the following proportion of cases: In 65 per cent of 34 cases in the vitallium cup group, in 87 per cent of 75 cases in the endoprosthesis group, and in 62 per cent of 52 cases in the skin arthroplasty group. Analgesics were still being used after the operation by 32 per cent of the patients in the first group, 27 per cent in the second group, and 31 per cent in the third group. Pain at rest was present in 12 per cent of cases in the first and second groups and in 17 per cent of cases in the third group.

2. To what extent has it been possible to increase the range of movement of the hip joint by the different arthroplasty methods?

Movements of the hip joint were determined according to the so-called mobility index values devised by GADE. Independent of the pre-operative values, on the whole the same mobility was attained after the arthroplasty. Even if the hip previously was quite stiff, it was approximately as mobile after the operation as the hips with better movements initially. In the latter the mobility did not notably improve. The average increase in the mobility index figures seen 12—23 months after arthroplasty was as follows: Vitallium cup group, 22.7; endoprosthesis group, 25.9; skin arthroplasty group, 24.7. These are equivalent, on the average, to about 100 per cent increase in the mobility.

3. What has been the opinion of the patients concerning the results obtained?

The patients were satisfied with the results of the operation as follows: Vitallium cup group, 68 per cent; endoprosthesis group, 69 per cent; skin arthroplasty group, 69 per cent. »Cannot say» was the reply of the following proportion of patients: Vitallium cup group, 23 per cent; endoprosthesis group, 23 per cent; skin arthroplasty, 27 per cent. The remaining small percentage of patients were dissatisfied with the result.

In cases in which the patient was very satisfied, the result evaluated according to the writer's criteria could in most cases be regarded as excellent. All cases in which the patient stated that he was satisfied could not be rated as good, and, on the other hand, the patients were not always dissatisfied with results which had to be considered poor.

4. What would appear to be the relationship of the three different arthroplasties to each other?

The literature dealing with arthroplasty gives an indication of the present opinion on vitallium cup and endoprosthesis arthroplasties. The findings in the present investigation conflict in no way with these opinions. Skin arthroplasty is a new method and so far there has been no knowledge of its value. In my opinion the present investigation demonstrates that it is possible to use skin as interposition material in arthroplasty, and even in a joint which is subjected to such severe weight-bearing as is the hip joint. It has become apparent, however, that skin arthroplasty of the hip joint requires after-treatment of another, more demanding kind than the earlier

methods of arthroplasty. The after-treatment conditions were poor. The results obtainable with skin arthroplasty can be improved by developing the operating technique and organising an effective course of after-treatment. The conservativeness of this biological method should be regarded as its unquestionable advantage over the earlier methods. The postoperative condition of a hip treated by skin arthroplasty does not place any restrictions on possible later operations.

5. What can be said in the light of the present investigation concerning free whole-skin grafts used as interposition material in arthroplasty?

No facts could be observed in the present investigation which would speak against the use of whole-thickness skin for the purpose in question. The interposition material, however, is only one of many factors which influence the result of an arthroplasty operation. Because of its weight-bearing, the hip joint is disadvantageous for experimentation with a new biological interposition material. Successful hip arthroplasty places considerable demands upon both the surgeon and the patient. It therefore does not seem likely that skin arthroplasty would appear more favourable than other methods in the hip joint in particular. On the other hand, the situation is a different one in smaller joints which are exposed to less stress. Observations that seem to point to this have already been made at our Clinic.

6. In what cases does hip arthroplasty appear to be worth performing and which one of the different methods would be most suitable in each particular case?

This question is a difficult one. It is self-evident that it is not worth while to make a poor arthroplasty. Also, one cannot demand that all the results would be excellent. Experience shows that many patients are indeed satisfied with a fair result. It is the surgeon's duty to make clear to his patient what result can in all probability be expected in his case. The patient must weigh the matter carefully from his own point, with consideration to the alternatives available. If the patient is uncertain concerning the arthroplasty, the result also will probably be the same. The patient must have the enthusiasm to actively help himself, especially in the heavy exercise treatment course, which demands will power. To care for his own share of the matter the patient must not only have strong determination but also intelligence. The prognosis of arthroplasty does not appear to be poorer even when the operation is made at a relatively late stage. Therefore there is time for deliberation and for attempting conservative methods of treatment.

The type of arthroplasty that would be most suitable in each particular case depends naturally upon the case. Vitallium cup arthroplasty would seem to be better suited than other methods for patients with a poor acetabulum. Endoprosthesis arthroplasty probably is serviceable only in the case of very aged persons, in whom the prosthesis can be expected last the necessary length of time. Best suited for skin arthroplasty would seem to be the cases in which the structure of the joint resembles the normal as much as possible.

In all the types of operation the length of the femoral neck is of essential importance. The static and mechanical factors in the hip joint must be carefully considered in every case.

XII. SUMMARY

The object of this work was to investigate the results obtained with a new method of arthroplasty in which whole-thickness skin with fatty tissue is used as interposition material, and which has been developed in the Orthopaedic Clinic of the University of Helsinki. Follow-up examinations were simultaneously made of the patients on whom alloplastic hip arthroplasty had previously been performed in the Clinic. Since furthermore nearly all the operations had been performed by the same surgeon, this provided a good opportunity to compare the results of the recent skin arthroplasties with those of the earlier vitallium cup and endoprosthesis arthroplasties.

After a survey of the literature on arthroplasties the writer reviews the publications dealing with the use of skin for this purpose. Skin was used already earlier as an interposition material in arthroplasties but the data on these isolated cases is limited almost to brief references only. Following a chapter describing the statics and mechanics of the hip joint the writer gives a report of his investigation. The series studied comprised all the hip arthroplasties performed in the Clinic during 7 years. In this period 171 arthroplasties were made on 163 patients, 103 of whom were women and 60 men. The oldest patient was 77 years and the youngest 12 years of age. The same surgeon performed 158 of the operations and the remaining 13 operations were made by four surgeons. The cases were distributed according to the type of arthroplasty as follows: 35 cases of vitallium cup arthroplasty, 83 cases of endoprosthesis arthroplasty, and 53 cases of skin arthroplasty. In 160 cases the indication of the operation was osteoarthritis, which in 84 cases was primary and in 76 cases secondary.

The follow-up examinations of these patients were made from 7 years to 1 year after the operation. A total of 94 per cent of the patients answered a questionnaire sent to them by the writer, and in addition 83 per cent arrived for a personal follow-up examination. The mean length of post-operative hospital treatment in the total series of 171 arthroplasties varied from 5 to 6 weeks in the three arthroplasty groups. The least number of

complications during this period occurred in the patients with skin arthroplasty, in whom the incidence was 11.3 per cent. There was no case of infection in this group. The endoprosthesis group included the only fatal case in the series, in which thromboembolism caused the patient's death 3 weeks after operation. Postoperative complications occurred in 15.6 per cent of the patients in this group, whereas in the vitallium cup arthroplasty group they occurred in 22.8 per cent.

Independent of the method of operation used, two-thirds of the patients stated that they were either satisfied or very satisfied with the result. An affirmative reply to the question whether the new joint felt natural was given by 81 per cent of the 52 patients with skin arthroplasty, 60 per cent of the 75 patients with an endoprosthesis and 44 per cent of the 34 patients with a vitallium cup who replied to the questionnaire. Work had been resumed on the average 6 months after operation. Nearly all the patients had resumed their previous occupation, a few young patients had learned a new occupation, and some of the older patients were pensioned.

Absence or definite relief of the preoperative pain was reported by 62 per cent of the skin arthroplasty group, 65 per cent of the vitallium cup group, and 87 per cent of the endoprosthesis group. The mobility of the hip joint was studied in the light of Gade's mobility index figures. Approximately the same mobility value was found in the three groups of patients at the follow-up examination independent of the preoperative mobility of the joint. In cases in which the hip before operation had been quite stiff it was after operation as mobile as the hips which initially had better movement. In the latter cases the mobility had not notably increased. The movements of the hip joint when the patient began weight-bearing improved slightly in the course of one year but then remained practically unchanged. The increase in the mobility was very similar in the three types of arthroplasty, the initial mobility being about doubled. The increase was 24.7 in the skin arthroplasty group, expressed in Gade's mobility index figures, 22.7 in the vitallium cup group, and 25.9 in the endoprosthesis group. Trendelenburg's symptom was positive at the follow-up examination in only 6 per cent of the patients.

In the patients with skin arthroplasty no new osteophyte formation was seen in the femoral head, and in only 4 cases they had developed on the rim of the acetabulum. After vitallium cup and endoprosthesis arthroplasties there was marked formation of osteophytes. In about every fifth patient with skin arthroplasty the joint space had become more distinct during the first year after operation. It is regarded as possible that also on man

the skin under favourable conditions may, due to function, develop into metaplastic cartilage, as has been shown by Kettunen in animal experiments in our Clinic¹. It was an interesting observation that a control roentgenogram in which the hip joint appeared unfavourable did not always signify an unsuccessful arthroplasty. Clinical experience definitely indicates that whole-thickness skin may safely be used as interposition material and that there is every reason to develop arthroplasty further on this biological basis. However, the interposition material as such is only one of many factors influencing the results of an arthroplasty.

¹ See also footnote on page 50.

XIII. ACKNOWLEDGEMENTS

I wish to express my sincere thanks to my father, Professor K. E. Kallio, for the clinical material placed at my disposal and for his constructive criticisms during the performance of this investigation.

Acknowledgement of good collegial co-operation is due to Kauko O. Ket-tunen, M.D., my fellow assistant at the Clinic, who investigated the subject of skin arthroplasty by animal experiments at the same time with this work.

The manuscript of this report was translated into English by Miss Elvi Kaukokallio.

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IMPORTANT CORRECTIONS

- Page 15, line 1. 17 cases *read* 17 per cent
- » 27, » 18. coxa vara *read* coxa plana
 - » 27, » 23. table 4 *read* table 3
 - » 37, » 3. followed *read* was followed
 - » 39, » 1. under anaesthesia *read* under general anaesthesia
 - » 44, » 10. Trendelenburg's signs *read* Trendelenburg's sign
 - » 49, table 14. **Poorer, No Change, Better *read* Better, No Change, Poorer**
 - » 53, line 3. quite stiff *read* practically stiff
 - » 86, » 6. » » » » »
 - » 90, » 23. » » » » »
 - » 93, » 21. Bernstein *read* Berntsen
 - » 99, » 3. Shephard *read* Shepherd