The following table, giving the sites of the lesions, is of interest.

TABLE VI.—*Reported Cases of Epitheliomatous Ulceration (1920-32)*

Site	Pitch	Tar	Paraffin	Mineral Oil		Total
				Cotton Mule- Spinners	Others	
Scrotum	125	110	10	487	60	792
Penis	2	10	—	14	4	30
Groin	2	3	—	10	2	17
Vulva	—	—	—	—	3	3
Eye and eyelid ...	45	14	1	10	2	72
Cheek	53	16	—	15	3	87
Lip	44	12	—	2	—	58
Head (scalp) ...	6	1	—	—	—	7
Forehead	8	5	—	1	4	18
Nose	32	7	—	5	3	47
Face	11	10	—	22	8	64
Chin	10	1	—	—	—	11
Ear	17	14	—	6	2	39
Neck	25	12	2	4	1	44
Arms (wrist) ...	20	47	14	68	8	157
Hand	10	22	5	22	10	69
Finger	4	4	—	3	1	12
Chest	1	—	—	1	—	2
Thigh	—	—	—	9	2	11
Knee	—	—	—	9	—	9
Leg	1	1	3	16	—	21
Foot (toe) ...	—	2	1	3	—	6
Multiple	29	14	1	8	4	56
Total	448	315	37	715	117	1,632

Preventive measures must be directed, of course, to the avoidance of contact with the carcinogenic agent, but by those acquainted with the industry it will be realized that it is almost impossible to ensure entire freedom from contact. There are no means available at the present time of eradicating this disease, but I think much can be, and has been, done by early detection and treatment. In Great Britain we have advocated and introduced extensively periodic medical examination of workers exposed to these carcinogenic agents. Cases of papilloma, or areas of keratosis, which may progress to malignancy, are in this way disclosed and treated. So far as I know, the treatment of choice is by radon. In the case of mule-spinners (those exposed to the mineral oil of self-acting mules) the schedule to the Workmen's Compensation Act has been extended to grant compensation for the period of treatment for early cases of papilloma or keratotic areas of the skin due to mineral oil. This, it is hoped and believed, will encourage treatment at an early stage. The judge or court has power to extend the fortnight of compensation if it is shown that a longer period of disablement is caused by treatment.

ANTHRAX

As regards the last of the occupational skin diseases with which I am concerned—namely, cutaneous anthrax—it would seem to me that this is in a different category. It arises among workers exposed to infection from infected wool, hair, hides, and skins. The cases of cutaneous anthrax notified in Great Britain during the last five years are enumerated in Table VII.

It is quite obvious that the only sure preventive measure lies in the disinfection of the infected material before it is handled. Disinfection, however, does not at present come within the realms of possibility for all classes of infected material. No practical method, for example, of disinfecting hides and skins has been devised,

TABLE VII.—*Anthrax*

Industry	1928	1929	1930	1931	1932
Wool	14 ²	16 ²	13 ¹	8 ¹	11 ¹
Horsehair	4 ¹	3	1	3	2
Hides and skins ...	24 ³	20 ³	24 ⁴	7 ¹	2
Other	3 ²	1	5 ¹	1	1
Total	45 ⁸	40 ⁵	43 ⁶	15 ²	16 ¹

The principal figures relate to cases, the raised figures to deaths.

although treatment with the sulphur lime process, in those cases where it can be applied, does seem to diminish the infectivity of hides. Some of you are no doubt aware that the Home Office has established a disinfecting station at Liverpool, dealing with certain classes of wool, and the extension of disinfection to others coming from infected districts is always under consideration.

While in Great Britain the general principles as to dust removal and cleanliness can be, and are, enforced by regulations, we cannot depend upon them to prevent entirely the occurrence of cutaneous anthrax. The disease does not, however, now present the problem that it used to do in the past, for the introduction of treatment by Sclavo's serum has, if the disease is taken in time, to a large extent eliminated a high mortality rate. Every effort, therefore, is necessary to ensure an early diagnosis of anthrax. Anthrax is by no means a common disease, and it is my experience that where fatalities do occur there has been failure to recognize the condition and a consequent delay in the patient receiving appropriate treatment. For this reason, in addition to notices exhibited in workplaces, where infected material is handled, the Home Office has designed a card which can be given to every individual worker. The object of this card is to hint to the medical practitioner invited to treat a local lesion in a worker exposed to risk that it is inadvisable to apply local treatment without at the same time eliminating the possibility of anthrax infection by means of a bacteriological examination.

These are, I believe, the principal occupational diseases of the skin. As I have already said, they present a difficult problem to those concerned with their prevention. They are also an economic factor of no inconsiderable moment. I have endeavoured to indicate, briefly, the general lines adopted in Great Britain to prevent, not only the occurrence of these cases, but also the severe results which occur if the primary condition has been neglected.

ROLE OF FUSION OPERATIONS AS APPLIED TO THE HIP-JOINT*

BY

MELVIN S. HENDERSON, M.D.

THE MAYO CLINIC, ROCHESTER, MINNESOTA

The invitation to address this Section and to open the discussion on the "Role of Fusion Operations as applied to the Hip-joint" is an honour which I deeply appreciate. My pleasure in accepting the invitation, however, is tempered by an uncomfortable feeling that I have nothing new to offer on the subject. Fusion of the hip-joint is not a common operation even in large surgical centres. As I stirred my memory I could recall the many difficult problems I had encountered in surgery of the hip-joint, my frequent indecisions as to the course to pursue, and, alas! the too frequent poor results which followed my best judgement and efforts. With such a background I

* Read in opening a discussion in the Section of Orthopaedics at the Annual Meeting of the British Medical Association, Dublin, 1933.

concluded that my best plan was frankly to present the results of those experiences in the hope that my audience might glean here and there something of interest and profit.

During the twenty-five years of my service in the Mayo Clinic caring for patients with orthopaedic disorders I can assure you that no patients have caused me and my colleagues more concern than those with lesions of the hip-joint, such as congenital, traumatic, inflammatory, tuberculous, osteoarthritic, or neoplastic. An operation on a hip-joint is a major surgical procedure, and the surgeon must be skilful and must exercise good judgement. While incoordinated haste may actually prolong the operation, safe speed is essential: prolonged operation on the hip-joint produces shock. Discussion of this topic is, in my opinion, timely. In view of the many more or less comparatively recent procedures in surgery of the hip-joint, such as the shelf operation for dislocated hips, congenital or paralytic, Lorenz's bifurcation operation, Schanz's osteotomy, the reconstruction operations of Whitman and Brackett, and arthroplasty for ankylosed and partially stiff hips, it would be well to discuss the part that fusion plays to-day in dealing with lesions of the hip.

PHYSIOLOGY

The function of the hip-joint is to furnish not only stability but mobility, the former to permit the erect posture and the latter to facilitate walking, sitting, stooping, and so forth. The joint owes its stability to the character of ball and socket, and to the tonic contraction of the surrounding muscles. A certain degree of negative intracapsular pressure in the acetabulum aids in keeping the ball secure, or dislocations would be more common in the flail-hips of paralysis. The ilio-femoral or Y ligament is important, for it prevents hyperextension, although reconstructed hips with good musculature following arthroplasty function without it. The most important function is stability, since mobility is not essential for walking; ankylosis in the favourable position of slight flexion and abduction permits an almost normal gait. Bilateral ankylosis is, of course, quite incompatible with anything approaching fair and comfortable locomotion. Motion without stability, as is encountered in infantile paralysis, causes a useless flail-hip. The muscles serve as the guy ropes to steady the pelvis on the weight-bearing leg, and when they fail the hip is useless for weight-bearing.

FUSION

Fusion may be employed for the sole purpose of furnishing stability, as in a paralytic flail-hip, which, although anatomically sound, is physiologically unsound. Or it may be employed in a hip definitely, anatomically, and physiologically unsound, as in tuberculosis, the object of the operation being not only to improve function by rendering usable a painful joint, but to eradicate disease. Fusion may be induced by any one of many operations, the technique varying. There are three main types of operation—namely, intra-articular, extra-articular, and a combination of these, called combined or mixed fusion.

Intra-articular Fusion.—The purely intra-articular type of operation consists of wide exposure and opening of the joint, manipulating the head out of the acetabulum, and removing the cartilage entirely; the same careful removal of the cartilage is carried out in the acetabulum (see Figure). The object is to obtain contact of the raw bone of the head to the acetabulum and thus give opportunity for fusion. The frequent cause of failure in these cases has been due, I believe, to the fact that, with the head smaller and the acetabulum larger, there is a misfit, and consequently insufficient and unstable bony contact. This may be partially obviated by roughening the freshened surfaces of bone on both the head and the acetabulum, a procedure which has the advantage of permitting the removal of pathologic debris and tissue such as is encountered in tuberculosis.

Extra-articular Fusion.—This particular technique has been advocated because of its supposed simplicity and because it enabled the surgeon to avoid opening the capsule; the latter was considered to be an advantage in tuberculosis (see Figure). Both these premisses are, I

believe, open to contention. There are two types of fusion. The para-articular, in which the bone graft is taken from some distant field such as the tibia, and the juxta-articular, in which the graft is taken from the wall of the ilium, as originally advocated by Albee, from the anterior superior spine as advocated by Ghormley, or from the great trochanter as advocated by Hibbs. The object of the operation is to obtain fixation of the joint by an extra-articular splint of bone

Three main types of fusion operation on the hip-joint.

bridging from the ilium to the femur. In performing this operation for tuberculosis, the site and extent of the disease are totally disregarded. Fusion of the joint surfaces is expected to follow the splinting action of the graft gradually.

Combined Intra-articular and Extra-articular Fusion.—This operation has the advantage of the two just mentioned (see Figure). The technique consists of removal of cartilage and exposure of denuded bone on the head of the femur and in the acetabulum. After the head is replaced in the acetabulum, a bone graft—obtained from the iliac wall, the anterior superior iliac spine, or the trochanter—is placed so as to bridge from the iliac wall to the femur as an additional guarantee for successful fusion. Experience in the Mayo Clinic has shown that in a series of cases of tuberculous hips in which this method was used, fusion was obtained more uniformly than by any other method, and just as quickly. Post-operative sinuses were less common, and when they did occur they healed in a shorter time than when the extra-articular method was used.

TREATMENT OF HIP LESIONS

In the Mayo Clinic from 1923 to 1932 inclusive, fusion of the hip was performed in the section on orthopaedic surgery on seventy patients; forty-three had tuberculosis of the hip, twenty-one arthritis due to some infectious process other than tuberculosis, three traumatic arthritis

following a fracture or a dislocation, two osteoarthritis, and one a dislocation due to infantile paralysis. The results are known concerning forty of the forty-three tuberculous patients and twenty-three of the twenty-seven non-tuberculous patients (see Table). They will be considered with the various types of lesions. There were no deaths that could be called surgical.

Seventy Consecutive Cases of Fusion Operation on the Hip-joint (1923-32)

Lesion	Cases	Results known	Fusion.		Comment
			Cases	Per cent.	
Tuberculosis	43	40	37	92.5	Intra-articular method in 1 case; extra-articular method in 23 cases; combined articular method in 19 cases.* Failure in 17.7 per cent.
Infectious arthritis	21	17	14	82.3	
Traumatic arthritis	3	3	3	100.0	
Osteoarthritis	2	2	1	50.0	
Infantile paralysis	1	1	1	100.0	—
Total ...	70	63	56	88.0	No deaths†

* Fusion time same, but fewer post-operative sinuses in combined method.

† One boy, aged 14, died ninety days after operation from disseminated tuberculosis.

Congenital Dislocation of the Hip

Irreducible congenital dislocation of the hip is a problem too frequently encountered. If the condition is unilateral, fusion is one of the methods to be considered for relief, but as I have never performed the operation for such a condition I cannot speak from experience. If the dislocation is bilateral the procedure may only be considered for one side. I have found the shelf operation so satisfactory that I employ it exclusively for irreducible congenital dislocations of the hip. Properly carried out it gives excellent function. So far as this condition is concerned, circumstances would have to be unusual to warrant the use of the fusion operation.

Infantile Paralysis

The residual paralysis following anterior poliomyelitis in the lower extremity is generally more severe and extensive distally, just the opposite of what occurs in the upper extremity. This fact reduces the cases of paralysed hips in which the fusion operation may be used to advantage to a comparatively small number. There is seldom any advantage in fusing a hip-joint if the knee and ankle below are also flail. It is only after most careful consideration that fusion of the hip should be undertaken in cases of infantile paralysis. Recurring dislocations in certain flail-hips can be prevented by fusion, but the shelf operation is preferred in America. In the series of cases reported here, one patient with double dislocation due to infantile paralysis was operated on; an infective process was also involved in this case. The result was good, but of course the operation was performed only on one side.

Traumatic Arthritis Due to Fracture-dislocations

Traumatic arthritis subsequent to a fracture-dislocation involving both the head and the acetabulum may be so painful that fusion is indicated. Many factors must be considered in the treatment, such as the social status and the age and temperament of the patient. The fusion operation is, I believe, first choice for this group, because remodelling and arthroplasty, particularly in cases in which there is much destruction of the surfaces of the joints, have been generally unsatisfactory. There is a tendency for callus to reappear after the operation, which

limits motion and causes pain. Fusion was performed in the Mayo Clinic on three patients with traumatic arthritis. All obtained ankylosis; they were free of pain and were comfortable.

Infectious Arthritides

Some patients with arthritis following systemic infections due to streptococcus, staphylococcus, pneumococcus, and gonococcus recover without significant injury to the joints. Usually, however, ankylosis or so much injury to joint surfaces remains that movement is limited and painful. The hip is involved fairly often. When the inflammatory process is thoroughly quiescent function may be quite good if the hip is ankylosed or merely stiff without pain in a position that permits of weight-bearing. If this more or less satisfactory condition exists nothing is to be done. There is a group of cases, however, in which, owing to faulty mechanics, either osteotomy or a fusion operation is indicated to permit comfortable locomotion. Some patients are fortunate enough to have a good range of motion with only slight pain, and by restricting their activities may so control the soreness as to be reasonably comfortable. It is better that the condition should remain as it is, for it is not of a progressive type. Fusion causes a painless weight-bearing hip without motion, and this may be a good substitute for a hip that is very painful on use, but it must be remembered that a stiff hip is a handicap. Recommendation of fusion in such cases calls for careful study of the patient, his daily life, and his ability to accommodate himself to his existing handicap. However, patients often put up with great discomfort because they think relief cannot be obtained; they do not appreciate what pain and inconvenience they have endured until they enjoy the relief following the fusion of the joint.

Twenty-one patients were subjected to fusion operations for infectious arthritis (see Table). The type of infection causing the arthritis could not be determined, for the patients were seen long after the acute phase of their trouble had developed. Fourteen are known to have ankylosis, four were not traced, and three failed to obtain fusion.

Atrophic Arthritis; Arthritis Deformans

It is usually possible to draw a sharp line between the so-called atrophic and osteoarthritic type of arthritis, but in certain cases a patient may have a combination of the two. The intra-articular involvement of the hip-joint in arthritis of the atrophic type is characterized by wearing away of the articular cartilages and deepening of the acetabulum with a consequent progression of the head toward the pelvic cavity. The proliferation about the line of the joint which occurs in the hypertrophic type is lacking. The pelvic bone may become thickened within the pelvis opposite the acetabulum as a protective measure to prevent the head from pushing its way through. The fusing of this type of painful hip will relieve the pain, but it must be remembered that we are dealing with multiple arthritis of the progressive type. I have seen patients who, after fusion of one hip, had trouble later with the other. Fusion should be undertaken with caution in cases of multiple arthritis, particularly if the knee and ankle are involved on the affected side.

I have classified cases of this type in the infectious group. There were only two of atrophic arthritis in which operation was performed. In both fusion was satisfactory, but in one the opposite hip became involved later as the arthritis extended; in the other the patient was satisfied, since the pain was relieved.

Osteoarthritis

This too common and disabling condition of the hip is variously named morbus coxae senilis, hypertrophic

arthritis, and so forth. Its treatment is so very unsatisfactory that it is only by exercising much restraint that I can keep my remarks within the bounds of this discussion. Briefly stated, there are three ways to deal with osteoarthritis of the hip: by manipulation, by plastic or reconstructive measures, and by fusion.

Manipulative measures may relieve pain in some of the earlier and milder cases. Plastic and reconstructive measures embrace excision of the osteophytic overgrowths called cheilotomy, remodelling and reducing the size of the head, excision of the head according to the technique of Whitman, and arthroplasty. All these methods have their staunch advocates. In fact, I have been almost startled by the satisfaction of certain eminent surgeons with their own favourite method of dealing with this most troublesome problem. I am free to confess that my own experience leaves me still far from satisfied with my efforts along these so-called reconstructive lines.

During the years covered by this study my efforts in dealing with osteoarthritis have been directed consistently toward preserving motion. I have used all the operations mentioned, with the result that function has been, on the whole, disappointing; although the pain was lessened, the results were not such as to awaken my enthusiasm. Brackett of Boston, in his study of painful hips, has approached the subject and presented his results in an impartial manner. He sums up the question as to whether "to fuse or not to fuse" a painful hip by saying that in the end "the individual makes the final decision." A stiff hip may be best for a labourer, but a hip with only a half or a third motion, even if slightly tender and painful, may be preferred by one whose work is in the office or the home.

At the Mayo Clinic fusion was done in only two cases of osteoarthritis. One operation was successful, ankylosis being obtained; the other failed, but pain was relieved. In the years previous to this report more fusion operations had been performed on patients with osteoarthritis, but, because of the occasional failure and the handicap of a stiff hip, I turned my efforts to the reconstructive type of operation to maintain motion. As I have stated, I am by no means satisfied with later results. Authorities agree that the obtaining of bony ankylosis in cases of osteoarthritis, particularly if patients are elderly, is not easy, for fusion often fails, and fibrous union only results. Subsequent adduction deformity in those cases in which fusion does not recur is therefore common.

TUBERCULOSIS

In tuberculosis of the hip lies the greatest field for fusion. Conservative treatment, although successful in arresting the disease or maintaining quiescence in a fair percentage of cases, nevertheless gives permanent relief in too few cases to permit its acceptance as the preferred method. In America, where the population is perhaps more restive than in Europe, and in our outlying districts where suitable provision for care is lacking, it is difficult to carry out consistently the proper conservative measures. Patients do not take kindly to the prolonged recumbency that is so necessary in the conservative treatment of the acute stage of hip-joint disease. Perhaps the real reason for this intolerance of protracted conservative treatment lies at the door of the medical profession. Smith and Watters in 1926 published a report from the New York Orthopedic Hospital of the end-results of the treatment by conservative measures in 150 cases of tuberculosis of the hip. This report indicated that something was wrong with our generally accepted methods. Twenty-four per cent. of the patients died, 47 per cent. still had active disease, 27 per cent. had the disease in a quiescent state with little if any motion, and only 2 per cent. were free of all symptoms. This report stimulated increasing interest in

fusion for tuberculosis of the hip. Fusion by natural processes, in my experience, has been extremely rare in tuberculosis of the hip. Fortunately, tuberculosis of the joints is on the wane in America; this is noticeable in our larger State and charitable orthopaedic hospitals.

An operation to produce fusion of the hip is a major procedure, and only patients in good general condition, without other active foci of tuberculosis and without draining sinuses, should be subjected to it. Many surgeons favour the extra-articular method, but it is my opinion that the combined intra-articular and extra-articular operation is the more suitable if the bone is tuberculous. One of my reasons for this preference is that it permits removal of the tuberculous material and caseating debris, and the curettage and obliteration of abscesses in bone. All cartilage can be removed from the head and the acetabulum, the bone can be freshened and roughened, and good contact can be secured. The bone graft can also be used to bridge from the ilium to the trochanter.

Fusion in cases of tuberculosis is fast becoming the generally accepted method for the adult, and the operation is gradually being used for children. Wilson in 1932, at the meeting of the American Orthopedic Association, reported a series of cases among children in which the extra-articular method had given very good results. At the same meeting I reported cases from the Mayo Clinic, mostly of adults, and attempted to compare the different types of fusion. The comparison, so far as it was possible to carry it out, showed that the radical or combined operation was just as safe as the more conservative operation.

There were forty-three cases of tuberculosis of the hip treated by fusion between 1923 and 1932 (see Table). The result was determined in forty cases, and in thirty-seven (92.5 per cent.) fusion occurred. One patient has a persisting sinus. Only one patient was operated on by the intra-articular method, twenty-three by the extra-articular method, and nineteen by the combined intra-articular and extra-articular method. In spite of the fact that the combined operation is a more extensive procedure than the extra-articular operation, the time required for fusion to develop was about the same; the results, however, were more certain, and the occurrence of post-operative sinuses was appreciably less.

SUMMARY

Fusion operations as applied to the hip-joint obliterate mobility but leave stability. The various types of fusion are: the intra-articular, the extra-articular, and a combination of the two called the combined (mixed) intra-articular and extra-articular. The last-named is to be preferred because it gives better opportunity for thorough and complete freshening of the surfaces of bone, and for the removal of pathologic tissue and debris.

Irreducible congenital dislocations of the hip rarely, if ever, demand fusion. The same is more or less true in cases of infantile paralysis, although a higher percentage of these cases is to be considered for fusion. Fusion is more often to be favoured for the traumatic arthritides following fracture-dislocations. If hips are painful following infectious arthritides, in atrophic arthritis, and in osteoarthritis, fusion plays a very definite part, but it must be borne in mind that the operation is a major procedure, and so carries a definite risk. Elderly patients with osteoarthritis may fail to obtain fusion even after a carefully planned operation. It is the operation of choice as a final resource, and it should be used only in severe cases and after most careful consideration. The patient's temperament, his social status, his method of living, his type of work, etc., should be investigated.

In tuberculosis of the hip lies the greatest field for fusion, particularly among adults. The operation should be used for children oftener than it is at present.