to enable one to see the foreign body, and obtain plenty of room for manipulation of instruments. If complete excision of the infected wound has been made under proper technique, one should be able to get first intention after suturing, however large the wounds may be.

5. Careful removal, under direct vision whenever feasible, of all foreign material, whether free in the joint or embedded in the articular surfaces. If the latter, the bone surrounding the foreign body must be carefully chiselled or gouged away, *en masse* if possible. The joint cavity is then flushed out with 5 per cent. saline, flavine solution, etc.

6. Closure of the wound in layers, using fine catgut for the synovial membrane. Drainage tubing should not project into the joint. Of course, if tubes are required for the introduction of fluid, as in the Carrel-Dakin method, they should be carried to the deepest recesses of the joint, or inserted through a fresh incision. They should be removed as soon as possible.

7. If the wound in the synovial membrane cannot be closed, a small "salt pack," separate from any other which may be required for the rest of the wound, should be inserted firmly "down to but not into" the joint, and should be left until it is absolutely loose. A small tube may be placed in the centre of the pack, reaching to the synovial membrane, and it may be removed in a couple of days. If attempts are made to pull the pack away, adhesions shutting off the main cavity of the joint are likely to be broken down, and infection is then liable to occur.

8. Tendinous or ligamentous structures exposed during operation should be covered by skin and subcutaneous tissue, otherwise they are very apt to slough, and this postpones closure of the wound, and therefore prolongs convalescence.

9. If there is much effusion into or from the joint, of whatever nature, or if raw surfaces, whether of bone or soft tissue, are left in the joint, at the end of operation, a tube should always be inserted "down to but not into" the synovial cavity. Pressure of effusion—that is, tension—must be avoided at all costs, because it interferes with healthy circulation in and absorption by the synovial membrane, and these are essential to successful combating of any infection which may have been overlooked.

10. The injection of ether, formalin-glycerin, or hypertonic (5 per cent.) saline solution into closed joints, is of doubtful value. They are all irritants. Success is claimed for all three, although their actions are different. The common factor in their application is preliminary aspiration of the joint. This removal of tension is possibly the explanation of their apparently beneficial action. It is possible, however, that the injection of or washing out by a non-poisonous, non-irritating antiseptic like flavine, whose antiseptic action is enhanced by mixture of the substance with body fluids, may be of great value in many cases.

11. The paramount importance of obtaining x-ray skiagrams has already been indicated.

Haemarthrosis with Small External Wound.

I should like to discuss just one other type of injury, that which produces haemarthrosis in presence of small through-and-through wounds, and where only slight damage to soft tissues or bone is present. If the effusion cannot be aspirated, owing to the fact that firm clotting has occurred, I believe that best results will be obtained by deliberately opening the joint, by free incision on one or both sides, washing out the clot with sterile salt or flavine solution, and stitching up again without drainage. If the wounds are very small, one need do no more than sterilize them superficially. Such a blood clot, after a few days, forms excellent pabulum for the growth of organisms, and, even though it does not become infected, it is often the cause of much distress and disability in later stages, owing to formation of intra-articular adhesions. Officers at base hospitals in France appreciate the disastrous results of insidious infection in such cases. Hospitals in England have beds occupied unnecessarily long, even by non-infected cases, because, owing to the adhesions, they require skilled massage and so forth. Arthrotomy in this type must not be undertaken lightly. Technique must be perfect, else dreadful disaster is incurred.

Retention of Cases after Operation.

Operated cases should be retained for at least twenty-four to forty-eight hours. Firm compression under a very thick layer of cotton-wool and fixation in the "Thomas outfit" should be employed. I believe that a pad of wool in the popliteal space, tapering to each end, tends to prevent suppuration tracking from the back of the joint. If the joint looks quiet at the end of twenty-four to forty-eight hours, and the general condition is good, the case may be evacuated.

While the "ham" splint of the outfit is best for transport and for cases in which the wounds are in front of the joint, yet if there is a large wound on the posterior aspect, the thigh and leg should be suspended on separate slings of perforated zinc, well padded and covered with jaconet, so that access to the wound is provided without running risk of moving the joint.

Gentle passive movement, to a few degrees at first, should be begun as soon as one is certain that the parts are healing aseptically.

Sepsis.

If sepsis develops, all wounds should be opened up freely, possibly bilateral openings should be made, and the synovial cavity treated by intermittent flushing with Dakin's solution, or, which may prove to be better, with flavine solution. If improvement does not occur within twenty-four to forty-eight hours, a transverse or flap incision should be made, followed by resection, as Colonel Fullerton has advised, or, after free division of the lateral and cruciate ligaments, by packing and fixing the joint in flexion in Hepburn's aluminium splint. If the articular surfaces of the bones have been injured, the former method is preferable.

In conclusion, I would urge again the importance of rigid technique, and the necessity for thorough and complete operation. Half measures are worse than useless. "All or nothing" is a sound watchword. If the fulfilment of these principles is not possible, far rather fix their limbs properly, and send all patients on for treatment at the base.

RESULTS OF SIXTY CONSECUTIVE CASES OF WOUNDS OF THE KNEE-JOINT.

BY

W. H. OGILVIE, M.A., M.B., B.Ch.Oxon.,

SURGEON, URGENCY CASES HOSPITAL FOR THE FRENCH, MEUSE.

In the eighteen months from July 1st, 1915, to December 31st, 1916, I have received into my wards sixty cases of penetrating wounds of the knee-joint in an unoperated condition. The greater part of these were from the Verdun fighting in 1916. I exclude from analysis cases which had been opened and drained at a clearing hospital, and also a certain number which got well with no further treatment than immobilization, and in which actual penetration of the joint was not certain. Apart from these exceptions, I have included all penetrating wounds of the knee which I have treated since the opening of the hospital. They were, as a rule, received in from twenty-four to forty-eight hours of being wounded.

Classification.

The cases naturally fall into the following classes:

- A. No bony injury, and no projectile included.
- B. No bony injury, but projectile included.
- C. Bony injury, no projectile included.
- D. Bony injury, with inclusion of projectile.
- E. Bony injury of the lower limb of such gravity that involvement of the joint is only of secondary importance, no functional result being possible. Here the saving of life and, if possible, of the limb as well, is the only consideration.

As regards the probable final result, the presence or absence of a bony injury is the chief deciding factor. In classes A and B, given an aseptic result, which should be obtainable if the wound is a recent one, a good movable knee is nearly always to be hoped for. In classes C and D the result will vary from complete mobility to complete stiffness, according to the nature of the bony injury—again

always provided that treatment has resulted in the abortion of infection. Where there is serious bony injury, even partial mobility means an uninfected joint cavity.

Classes A and C differ, however, from B and D in that in the former operative interference should be avoided if possible, and if undertaken should in the first instance be limited to measures directed to cleaning the track; it is far better to leave the joint cavity alone if there is any reasonable probability of its being uninfected.

In classes B and D operation for the removal of the foreign body is necessary in the majority of cases. If, however, having traversed the joint, it is found to be extra-articular, and at the same time is small and not obviously the seat of infection, it is far better to be content with immobilization and dressings till all reaction has subsided. The projectile can then be removed aseptically at a later date.

Methods.

I have attached the greatest importance to immobilization—the most complete that it is possible to obtain. Any form of splint which rests upon the bed does not satisfy this requirement, as, however perfectly it may be fixed to the limb, any shocks or jars of the bed or its neighbourhood are communicated to the leg, while voluntary movements of the patient or necessary nursing attentions must cause at any rate some disturbance to the injured part.

In all cases of penetrating wounds of the knee-joint I have slung the whole limb from a rigid frame attached to

Fig. 1.—Blake fracture splint.

the bed. The apparatus I have employed is the form of bar splint used by Mr. Blake at the American Ambulance, Neuilly, Paris, which consists of two parallel bars of iron 9 mm. in diameter, free at the lower end, and connected at the upper end by a U piece set at an angle which fits the posterior aspect of the thigh at the level of the tuber ischii.

Fig. 2.—Footpiece as used for traction. For knee cases wood piece is screwed on.

The whole is bent out of one iron rod, and I have them made locally by a blacksmith at a cost of 3 francs. This splint is cheaper to make, easier to apply and to sling, and more comfortable in use than the Thomas knee splint. When using this splint for wounds of the knee I fit a sliding footpiece (Fig. 2) to which the

foot is fastened by adhesive strapping at the time of operation. Above this I have three semicylindrical sections of thin aluminium sheeting, hinging on the inner bar and clipping on the outer one. The upper one supports the thigh, the lower one the calf and ankle, and the middle one, when unclipped, exposes the posterior aspect of the knee, and allows the most extensive dressings to be done without the slightest disturbance to the limb. The aluminium sections give a rigid support far superior to bands of flannel or canvas

Fig. 3.—Splint arranged for wound of knee-joint.

they are easily cleaned and sterilized, and they form no obstacle to x-ray examinations in the splint. The whole splint is slung by two weights running over pulleys, the upper one of about 4 lb., the lower one of about 8 lb. Those in the illustration (Fig. 4) are 75 mm. shell cases, which, used empty for the former and filled with metal fragments for the latter, give the exact weight required. The upper weight keeps the U piece constantly on the tuber ischii, and allows the splint to follow every movement of the

patient's body, as when he goes on the bedpan. The lower is adjusted so that the foot of the splint will stay in any position in which it is put, and makes it an easy matter to raise or lower it for dressings. I have several times been astonished at the way in which a case which was doing badly on a fixed splint immediately started to improve when slung in this way.

In operating, the wound is regarded as consisting of two distinct portions—the extra-articular, where infection is

Fig. 4.—Splint in use; showing manner in which the splint is slung.

parried and repair instituted by the establishment of granulations; and the articular, where infection is combated by the action of the synovial membrane and its secretion, and where the establishment of granulations, though possibly beneficial in other ways, means impairment or loss of function in the joint as such. The extra-articular wound is accordingly cleaned and drained, the articulation is cleaned, closed, and allowed to fight its own battle. Drainage means throwing the two parts into one, with a likelihood of the same process being established in

Fig. 5.—Splint in use; showing ease with which wound may be dressed.

both. The synovial membrane has a surprising power of combating infection, especially, it appears, infection by gas-forming organisms. But to give it a fair chance it must be spared all avoidable injury:

1. Extensive incisions, retracting or holding the edges with clips to see into the joint.
2. Lengthy exposure.
3. Bleeding, and the consequent swabbing of the synovial surface.
4. Application of artery forceps.

These sources of damage are all reduced to a minimum if a tourniquet is applied in every case and x-ray localization is carefully done.

5. Leaving foreign bodies in contact with it—drainage tubes or accidentally included foreign matter.

6. The use of antiseptics.

In operations for the removal of foreign bodies included in the joint the procedure has been as follows:¹

1. The track is excised as far as the capsule with knife or scissors, only bruised or soiled tissues being cut away. The wound is then swabbed out with 5 per cent. iodine in spirit.

2. With a fresh set of instruments the joint is now opened, blood clot shelled out, and the projectile, together with bits of cloth and loose bone fragments, removed. If the projectile is far from the entry wound, it often saves injurious handling, after excising the track, to enter the joint through a fresh incision, which may later be sutured completely, being presumably clean.

3. The joint is irrigated with about two pints of 5 per cent. saline to wash out blood, cloth, and bacteria.

4. The wound in the synovial membrane is approximated with sutures. The track, if large, may be closed somewhat, the object being to leave it a funnel shape, with its apex at the wound in the synovial membrane and its widest part at the surface. It is loosely packed with gauze soaked in 5 per cent. saline.

5. 10 c.cm. ether is injected into the joint with a needle and syringe at some other part.

6. The limb is wrapped in cellulose tissue, an excellent absorbing medium, fixed in the sectional splint, and slung while the patient is still under the anaesthetic.

Afterwards, the outer cellulose dressings are changed daily and the plug moistened with saline. In four or five days it slips out easily, and may be replaced by a small wick. Fluid always fills the joint for the first few days, but does not often require aspirating.

I have always left the joint undrained as long as possible, as a drained joint nearly always means a stiff joint. Once it is certain that the resistance of the synovial membrane to infection has been overcome, I open the joint by an incision above the patella, and a lateral incision each side as far back as possible. Rubber tubes split longitudinally—not holed, for a holed tube is soon anchored down by granulation buttons and completely blocks drainage—are inserted from the upper opening to each lateral one, passing through the joint. Good drainage is now a prior consideration to avoidance of injury to the synovial membrane. A few drops of saline are run down these tubes each day, but beyond this nothing is done. The knee-joint is too complex a cavity to offer any hope that syringing or continuous irrigation will in any sense wash it through; the only effect of these measures is to set up eddies which wash infection into places which it perhaps has not yet reached, and to start tracking along muscle planes. It is safer to ensure that such flow as there is in an outward direction; this is done by free openings and really complete immobilization.

Resistance of the Knee-joint to Gas Infection.

Two cases were remarkable in that in each instance wounds of the thigh muscles and the knee-joint, occurring in the same leg and caused by the same projectile, gave rise in the muscular tissues to a virulent gas infection and in the joint only to a serous reaction. Another case arrived twenty-four hours after being wounded with several bits of bomb in the outer side of the right lower limb. Those in the leg and thigh showed a local gas infection. One piece had penetrated the external lateral ligament and was projecting into the joint, which was tightly distended with gas. The projectile was extracted by the entry wound. On the experience of former cases, the joint was not drained, but the gas and fluid were drawn off with a trocar and cannula. A tube and funnel were then joined to the cannula, the joint repeatedly washed out with saline, and ether injected. Recovery was without incident, and on evacuation to the interior the man was walking with an almost complete range of movements, which would certainly become perfect with massage.

Results.

Clean movable joints	...	...	33
Clean joints with limited mobility	...	...	5
Stiff limbs	...	...	17
Amputations	...	...	3
Deaths	...	...	2

Three of the 60 cases belong to Class E. Their discussion does not come under joint surgery, but I have included them so as to make the series a complete one of every fresh case treated in which the knee-joint was involved. Omitting these, there are one death and two

amputations in 57 cases. The death occurred on the eighth day from an acute dysentery. The knee-joint was not only clinically clean, but *post mortem* contained only serous fluid.

Of the amputations, in one there were multiple wounds of the left lower limb. On arrival there was a cellulitis extending from the ankle to the middle of the thigh. A large bit of shell had chipped the external condyle and head of the tibia, and there was pus in the joint. Four-hourly fomentations were applied to the whole limb for a week, rendering real immobilization impossible.

In the other case I blame myself for not having discovered at an earlier date that the joint was infected. There were small wounds all over the front of the right thigh which revealed nothing to the x rays. After fifteen days I operated and found a track containing mud and gravel leading into the suprapatellar pouch, and a mild infection of the joint. His low condition made amputation advisable six weeks later.

From the point of view of the classification given above the results are:

Class A (10 cases):

Clean movable joints	...	...	...	6
Limited mobility	...	...	...	1
Stiff limbs	...	...	...	2
Amputation	...	...	...	1

Class B (19 cases):

Clean movable joints	...	...	...	15
Limited mobility	...	...	...	2
Stiff limbs	...	...	...	2

Class C (7 cases):

Clean movable joints	...	...	...	3
Stiff limbs	...	...	...	4

Class D (21 cases):

Clean movable joints	...	...	...	9
Limited mobility	...	...	...	2
Stiff limbs	...	...	...	8
Amputation	...	...	...	1
Death	...	...	...	1

Class E (3 cases):

Stiff limb	...	...	...	1
Amputation	...	...	...	1
Death	...	...	...	1

Owing to consideration of space, the summary of cases accompanying this article has been omitted. The illustrations are the work of Orderly E. D. Wookey, to whom the author wishes to express his thanks.

REFERENCE.

¹ Colonel H. M. W. Gray: 'Treatment of Gunshot Wounds of the knee-joint, BRITISH MEDICAL JOURNAL, July 10th, 1915, p. 41.

THE TREATMENT OF GUNSHOT WOUNDS OF THE KNEE-JOINT.

WITH AN ANALYSIS OF SEVENTY CASES.

BY

CAPTAIN C. MAX PAGE, M.S., F.R.C.S., R.A.M.C.(S.R.).

The outcome of wounds of the knee-joint during the present war has, on the whole, been a source of surprise and satisfaction.

The extent of the articulation makes any general infection of it the source of profound toxæmia, and its anatomical complexity renders surgical treatment, when necessary, difficult.

For these reasons civil experience has led to a profound distrust of the ability of this particular joint to deal with infective processes. This attitude was, it appears, based on an experience of the comparatively exceptional cases in which general infection had taken place in a practically closed joint. Intensive practice under war conditions, however, has shown that when rational measures are adopted at an early period, infection of the knee and other joints can in the presence of an open wound become limited and be dealt with by the natural defences in a remarkable way.

Nevertheless, for reasons not always avoidable, general infection of the joint does occur in a certain proportion of cases—in this series, 37.7 per cent.—and the results collected for one base over five months show that we have by no means arrived at a generally satisfactory method of