Medicolegal Aspects of Lower Extremity

Henry H. Kessler
Physiology

Chief Functions. The lower extremity serves two fundamental purposes: (1) the support of the trunk and the upper part of the body, and (2) locomotion. In order to carry out these functions the lower extremity is intimately connected with the static arrangement of the skeletal components of the whole body in order to maintain equilibrium. Even when the body is at rest in a standing position, it is kept at rest by the muscles overcoming the force of gravity. The practical application of this fact to the end results of trauma lies in the preservation and constancy of the centers of gravity for the different skeletal components and the composite center of gravity for the body as a whole. The shifting of these centers by displacements or malalignments from fracture or by the shortening of bone or muscle following injury, produces a rearrangement of the static and dynamic conditions. The resulting pain and strain cause disability, fatigue, limp, and impaired function of the limb.

Comparison with Upper Extremity. While the chief function of the upper extremity lies in its mobility, that of the lower is to afford stability. A non-union of the arm or forearm constitutes a serious handicap but not an insurmountable one insofar as the active use of the member is concerned. The same condition in the leg or hip is a complete obstacle to walking.

Ankylosis. On the other hand ankylosis in the lower extremity is a less serious disability than in the upper extremity especially if it is in a good position. The function of an ankylosed limb depends upon its position. Ankylosis of the hip or knee in flexion is a serious disability and cannot be compensated for except by crutches.

Shortening. While the effect of shortening in the arm is negligible, in the leg it is very important. A small degree of short-
ening in the leg may be compensated for by a tilting of the pelvis, but if the amount of shortening is great, the tilting may be accompanied by muscular changes due to strain which may cause permanent impairment of working capacity.

Other Functions. The functions of the lower extremity include not only standing and walking but also jumping, climbing, walking on the upgrade and downgrade, with and without a load, as well as swimming and crawling. However, for our purposes in evaluating disability it will be more practical to confine ourselves to the chief functions of the lower extremity, namely, weight bearing and locomotion.

Relative Values. Injuries of the lower extremity while causing longer temporary disablement nevertheless cause less permanent impairment of the individual's general capacity to work. It is for this reason that greater weight is given to the upper extremity in the actuarial schedules of both private and government insurance agencies throughout the world.

ELEMENTS OF EVALUATION

General Considerations. The general principles of estimating permanent disability in the upper extremity apply also to the lower extremity. The same factors, motion, strength and coordination are utilized to determine the loss of function.

Motion. Motion in the hip, knee and ankle joints of the injured extremity is measured and compared with the sound limb and computed as in the upper extremity. The entire joint is given a value of $33\frac{1}{3}$ per cent. The motion of the hip consists of flexion, extension, adduction, abduction, and internal and external rotation. The loss of the specific motion that is greatest is considered as the loss of motion for the whole joint. The same holds true for the knee joint where only two motions are involved, flexion and extension, and for the ankle joint where in addition to flexion and extension there are inversion and eversion. Following a fracture of the middle third of the femur the following defects in motion may be present: 30 degrees loss of flexion at the hip and 25 degrees loss of motion in the knee. Degrees of lost motion for the individual arcs of movement must be translated into percentages of lost motion for each joint, namely, 25 per cent for the hip and 20 per cent for the knee respectively. These are added as follows, 25 per
cent of 33\(\frac{1}{4}\) (the value of the whole hip joint) and 20 per cent of 33\(\frac{1}{3}\) (of the knee joint) or approximately 15 per cent.

**Strength.** This is measured with a spring balance. The muscle groups that are tested are plantar and dorsal flexion of the ankle, flexion and extension of the knee, flexion and extension and adduction and abduction of the hip.

**Coordination.** As a rule coordination as exemplified in gait is little impaired in injuries of the lower extremity. Gross disabilities from lack of coordination are more likely to be due to cerebral or spinal cord lesions. Measurement of this factor therefore is unnecessary unless of a degree marked enough to be obvious on inspection. Amar and Schwartz have devised ingenious technical methods for the accurate determination of gait and coordination in the lower extremity which however do not lend themselves to practical purposes. A simple method for making this determination is to have the patient walk a straight line for thirty-three steps and multiplying the number of missed steps on the line by three to serve as an index of gait and incoordination. If eight steps are missed the percentage is 3 x 8 or 24 per cent. The test should be repeated three times and the average taken.

**Weight-bearing.** - The three factors, motion, strength and coordination, correspond to those in the arm radical of the upper extremity. Stability, or weight bearing, the foot radical, has the same relation and importance in the lower extremity as prehension in the upper extremity.

Weight bearing may be tested in two ways. (1) The patient is put on his back, the leg held with the knee stiff in extension; the loop of the spring balance is passed around the heel of the foot to be tested, the foot and knee steadied and the operator standing at the head of the patient exerts a gradual tension in the horizontal plane until the knee gives or bends. The reading is then taken and compared with the other leg. For example, normal leg, 120 pounds, affected leg, 80 pounds, percentage loss 30 per cent. (2) A simpler method is to have the patient stand on two bathroom scales with his feet spread about one foot apart. The difference in reading of the two scales after three trials is taken as the loss in weight bearing of the affected member. For example, normal leg 100 pounds, affected leg 75 pounds, loss equals 25 per cent. The disability of the entire lower extremity depends upon the maximum disability
between the leg radical and the weight bearing or foot radical. The following examples of disability will clarify the method.

1. Fracture of the upper third of the femur, poor position.

<table>
<thead>
<tr>
<th>Leg radical—motion</th>
<th>Strength</th>
<th>Coordination</th>
<th>Weight bearing</th>
<th>Entire extremity</th>
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Entire extremity 21

2. Synovitis of knee.

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<th>Strength</th>
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Entire extremity 16


<table>
<thead>
<tr>
<th>Leg radical—motion</th>
<th>Strength</th>
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Entire extremity 30

4. Paralysis of external popliteal nerve.

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<th>Weight bearing—foot radical</th>
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Entire extremity 15

5. Fracture of os calcis.

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Entire extremity 40
6: **Severe sprain of ankle.**

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<td>Entire extremity</td>
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With a working knowledge of these principles, the end results of injuries to the lower extremities may be now evaluated.

**Fractures of the Lower Extremity**

**Pelvis**

*General Prognosis.* The prognosis of fractures of the pelvis depends largely on complications, especially those involving the viscera in the abdomen and pelvis. A simple fracture of one ramus or of the isolated parts of the pelvis heals quickly, generally with no functional disability despite the fact that the X-ray reveals deformity of the fracture site.

*Complications.* Injuries to the urinary tract may cause rupture of the bladder and urethra while complicating abscesses may develop from extravasation and also from osteomyelitis of the pelvic bones. Injuries to the psoas muscle are less common. Injury to the bowel is still less rare, while nerve injury to the sacral plexus is still more rare.

*Average Period of Incapacity.* The temporary disability varies according to the type and severity of the fracture as follows:

1. Isolated fracture of the pubis, eight to ten weeks.
2. Pubis and ischium, eight to ten weeks.
3. Isolated fracture of the ischium or ilium, six to eight weeks.
4. Isolated fracture of the sacrum, eight to ten weeks.
5. Fractures of the acetabulum, three to four months.
6. Double, Malgaigne, fractures (through the entire pelvis on both sides), four to six months.

*Permanent Disability.* The estimation of permanent disability in fractures of the pelvis must be based on arbitrary factors such as pain, difficulty in walking, restriction of hip motion, shortening of
the affected limb and muscular atrophy of the hip and thigh. However the general capacity to work may be gauged by an actual demonstration on the part of the patient in a workshop under supervision or observation. Exact methods as prescribed for the upper and lower extremity are not applicable unless the disability is localized in the extremity proper. The estimates must be made in terms of one hundred per cent working efficiency. In a series of one hundred twenty-one cases these estimates ranged from five per cent in the mild cases to forty per cent in the severe cases.

**Femur**

Fractures of the femur may be best classified anatomically into three groups according to whether they involve the hip-joint, the shaft of the femur or the knee-joint.

**Upper End of Femur.** These fractures may be further classified according to the location of the fracture.

- Fracture of the head of the femur.
- Slipped epiphysis.
- Fracture of the neck of the femur.
- Intertrochanteric fracture.
- Fracture of the greater trochanter.
- Fracture of the lesser trochanter.

**Head of Femur.** These cases are extremely rare. The complication is usually that of arthritis of the hip joint with a residual painful and stiff hip.

**Slipped Epiphysis.** Slipped epiphysis is however more common though it is confined to growing adolescent children. Its traumatic origin has not been entirely accepted since the slipping and subsequent separation can occur without injury. Due to constitutional factors such as low grade infection, circulatory disturbance and glandular disorders the epiphyseal junction becomes loosened and progressively worse due to the simple effect of carrying the body weight.

**Average Period of Incapacity.** In a case treated early, the temporary disability is comparatively short. With reduction and immobilization, weight bearing can be begun in about eight weeks. The additional burden of carrying or lifting weights makes return to work at this time dangerous and inadvisable. Four months then
is the period estimated in the more favorable cases. In untreated cases this period is prolonged.

**Permanent Disability.** The most frequent after effects of slipped epiphysis from a gross functional standpoint are limitation of motion at the hip, and pain on weight bearing. General muscular weakness of the extremity is an added factor. The limitation will depend on the extent of the displacement, the success of reduction as well as associated injury to the joint capsule as a result of manipulative procedures. The limitation is most marked in abduction, other motions being only slightly affected. Pain although not always present is most frequently due to abnormal muscle strain. Associated muscle weakness is due to alteration in the lines of weight bearing accompanied by the change in anatomical relationship between the neck of the femur and the shaft. Normally this angle is about one hundred thirty-five degrees but as a result of this lesion the angle is reduced practically to a right angle producing the condition technically known as *coxa* (hip) *vara* (turned in).

The estimation of permanent disability as measured by the functional factors of leg and foot radical range from twenty-five to forty per cent.

**Neck of the Femur.** This is the most important of the fractures at the upper end of the femur. The majority of these fractures occur in old people. This is due to changes that have taken place in the bone from impaired nutrition causing a thinning out of the mineral salts (lime) that form the firm substance of bone. The impaired nutrition is secondary to changes in circulation as frequently occur in arterio-sclerosis (hardening of the arteries) which is common in aged or aging people.

The site of the fracture is very important because the prognosis is intimately related to this factor. Fractures which occur close to the head of the femur do poorly and rarely unite without surgical intervention. Fractures which occur farther along the neck nearer the trochanters have a much better prognosis. This is due to the better distribution and location of the blood supply, in the latter location. In fractures close to the head (intracapsular, or subcapital fractures) the fracture interrupts the blood supply coming from the capsule so that the head depends for its blood supply on a very small vessel running through a ligament, the ligamentum teres which runs from the center of the joint to the center of the head of the femur. For biologic reasons this vessel is absent in about twenty-
five per cent of all people. In patients who have no blood supply to the head the latter will degenerate and thus be unable to assist in the physiologic process of uniting with the neck portion of the femur. On the other hand, fractures close to the shaft have their blood supply intact so that union is more likely to occur.

Some of these fractures occur in such a manner that the neck and head are impacted one into the other. These are the most favorable cases, require no treatment other than rest in bed and freedom from weight bearing. Union invariably takes place.

Treatment for many years of fracture of the femur had been so unsatisfactory the name “unsolved fracture” had been given to it. However with proper reduction and the use of internal fixation by means of nails of various descriptions the outlook has been considerably improved.

**General Prognosis.** Many other factors enter into the problem of prognosis. The presence of impaction, prompt recognition and prompt and proper treatment are as important as the anatomical site. However even despite good and prompt treatment absorption of the neck frequently takes place with resultant non-union.

**Complications.** In addition to non-union there is an added risk in fracture of the neck of the femur which is not present in most fractures. Death may occur within a few days, the patient succumbing either to shock or pneumonia. Occasionally death occurs later without any apparent specific cause, the patient gradually declines, his strength fails. Sometimes he goes into a mild delirium and sometimes he has changes in the lungs suggestive of pneumonic consolidation.

**Average Period of Incapacity.** Even in the most favorable case, union is not firm for a long time although X-ray evidence of union is present. The limb must be protected by a suitable brace and the patient must give suitable evidence of weight bearing before being sent back to work. Four months of immobilization and freedom from weight bearing and an additional four months of weight bearing with support are a minimum period.

In the presence of non-union the temporary disability should extend for an additional period of eight months after surgical correction.

**Permanent Disability.** Fractures of the neck of the femur with good bony union may improve with time, to a point where even
complete restoration of function occurs. Such a favorable outcome is unusual. Old people who have sustained a fracture of this kind have to go to bed on account of pain. They soon lose courage and confidence in themselves. They may have been steady workers before their accident and may have gone on to a ripe old age. Now they find it difficult to raise their leg, let alone walk, and when they find themselves so afflicted they are loath to leave their crutches. This mental attitude is due to real causes. On the other hand with a better mental attitude and a good bony union the claimant may return to his former work. The functional result can then be estimated in terms of the motion of the hip, strength in the muscles and the ability to bear weight.

The following were the end results of eighty-six cases of fracture of the neck of the femur:

1. Good bony union—50 cases

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<th>Percentage Range</th>
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<td>1—10 per cent</td>
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<td>17—33 per cent</td>
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<td>15—20 per cent</td>
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<td>85 per cent</td>
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2. Incomplete union with good function—6 cases

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<td>4—15 per cent</td>
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<td>66 per cent</td>
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3. Incomplete union with poor function—30 cases

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<th>Percentage Range</th>
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<td>6—85 per cent</td>
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<td>90 per cent</td>
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<td>100 per cent</td>
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Intertrochanteric Fracture—General Prognosis. Intertrochanteric fractures have excellent prognosis both regarding union and ultimate function. The large blood supply and the presence of many muscular insertions about the intertrochanteric region are factors responsible for good end results.

Average Period of Incapacity. These fractures require a shorter period of disability than fractures of the neck of the femur. Where the minimum for the latter would be about eight months, only four months to six months are the requirements.

Permanent Disability. Because of the powerful union of the fracture, weight bearing is rarely interfered with unless there is marked shortening. The most frequent causes of disability are muscular weakness and limitation of motion at the hip. These impairments however are rarely marked except in the aged. In fifty-six cases of intertrochanteric fracture the following were the estimates of permanent disability based on the functional factors of motion, strength, coordination and weight bearing.


1—5 per cent 31—15 per cent 1—33 per cent
18—10 per cent 4—25 per cent 1—50 per cent

Greater Trochanter—General Prognosis. Fractures of the greater trochanter are uncommon. When it occurs it is usually the result of muscular action. The disablement that follows is significant because of the attachment of the gluteus medius and gluteus minimus muscles to the detached fragment of bone. The disability consists of the loss of power in abduction and extension of the hip. Weight bearing itself is not disturbed, since the shaft of the bone is intact.

Average Period of Incapacity. This ranges from the minimal case of four weeks duration to eight weeks in the average case in the absence of complications.

Permanent Disability. Occasionally union is only fibrous but even with good bony union some weakness in the musculature persists. Disabilities range from five to twenty per cent.

Lesser Trochanter—General Prognosis. This too is a rare injury due to muscular violence, due to the pull of the iliopsoas muscle which is attached to the lesser trochanter. Because of powerful muscle pull the fragment is frequently displaced considerably. In this case a moderate degree of muscular weakness persists. However, due to the large number of other muscles which have an analogous function, this muscular weakness is never serious.

Average Period of Incapacity. The average cases heal in six to eight weeks.

Permanent Disability. Weight bearing is not interfered with. The chief disability lies in the muscular weakness. Disabilities range from fifteen to twenty per cent.

Shaft of the Femur—General Prognosis. These are classified into those of the upper end of the shaft, the middle of the shaft and the lower end of the shaft since the prognosis varies with each type of fracture.

Upper End of the Shaft. Subtrochanteric fractures (those occurring just below the greater trochanter in the main shaft of the bone) are important because of the frequent deformity that follows. They are also significant because they are sometimes associated with pathological conditions as Paget’s Disease or malignancy. The fractures in these latter instances are called pathological since the solution
of continuity is due to the giving way of the diseased bony tissue rather than from the severe violence of the injury.

Middle of the Shaft. The chief characteristics of fractures in this region is the marked shortening resulting from poorly reduced fractures. Angulation of the fragments with altered lines of weight bearing are another end result.

Lower Third of the Shaft. These fractures are significant since they invariably involve the knee joint.

Sequelae. Fractures of the shaft of the femur may result in a functional disability manifested in a variety of ways. Shortening is common, ranging from a negligible amount to four inches. Muscular atrophy is a frequent concomitant especially localized in the quadriceps muscle. Edema (boggy swelling) is less frequent than in fractures of the leg below the knee. Restriction of motion is generally persistent in fractures of the upper end of the shaft and the lower third of the shaft. Instability of the knee occasionally follows fractures involving the lower third of the femur. Effusion of the knee joint while accompanying fractures of the lower end of the femur is generally due to direct injury to the knee joint. Pain may be due to vicious union, to soft callus which yields on weight bearing or due to muscular strain from altered lines of weight bearing following deformity. Vascular injury is an uncommon complication manifesting itself in swelling, pain, discoloration and “cramps.” Paralysis of associated nerves is rare, except in compound fractures.

Average Period of Incapacity. The average period of incapacity of fractures of the shaft of the femur is six months. In the presence of vascular injury, joint involvement, vicious union, this may extend to a year.

Permanent Disability. In a series of 164 cases the estimates were made on the basis of the loss of function. This varied from 5 to 100 per cent with the average 33 per cent.

Knee

General Prognosis. Under this heading are included all fractures of the lower end of the femur, the patella and the upper end of the tibia and fibula.

All three types of fracture affect the integrity of the knee-joint. The end result of these fractures is manifested in a restriction of
motion due to collateral injury to the soft parts or to bony block following displacement, complete ankylosis, instability of the knee, weakness of the quadriceps muscle, bony deformity such as bow leg or knock knee causing static strain on the extremity or the whole trunk.

Average Period of Incapacity. The temporary disability is prolonged, ranging from two to four months in the average case and six to eight months in the complicated case.

Permanent Disability. Any fracture which involves the knee is serious and rarely heals without pain, stiffness and muscular atrophy of the thigh. When the atrophy is moderate and the stiffness does not hinder flexion very much, the industrial incapacity is also moderate. In eighty-six cases the disability ranged from fifteen to one hundred per cent with an average of thirty per cent.

Complete bony ankylosis is uncommon but when it does occur the resulting disability will depend in large measure on the position of the ankylosed limb. If the knee is anklyosed in extension (the straight position) the disability is about forty per cent and this is the most favorable position. If the ankylosis occurs in a markedly flexed position the disability is severe ranging from sixty to seventy-five per cent.

The Patella

General Prognosis. The patella is unlike any other bone in the body. It is a sesamoid bone and forms part of the great tendon of the quadriceps muscle which eventually inserts in the tibial tubercle on the anterior surface of the tibia close to the knee joint. A fracture of the patella cuts it in two and thus interrupts the continuity of the quadriceps muscle and tendon. The object of treatment is to repair the tendon which has been severed. Unless this is done the quadriceps muscle cannot act. It cannot extend the leg, raise the body from a crouching position or raise the toes from the level of the bed. These cases should therefore be operated to secure satisfactory repair.

Average Period of Incapacity. In fractures of the patella treated by closed reduction (without an open operation) the average disability period is four months. These cases generally heal by fibrous union and frequently refracture. In operated cases the disability averages three months.
Permanent Disability. Atrophy of the quadriceps and restriction of motion are common sequelae. The restriction of motion is especially marked when the knee has been immobilized in a plaster cast for more than three weeks. The average disability ranges from twenty per cent in the operated cases to forty per cent in the non-operated cases.

Semilunar Cartilages. These crescentic shaped pieces of fibrocartilage act as washers in the knee joint to provide a more perfect fit between the condyles of the femur and the tibia permitting them to lock into position when weight is borne on the leg. Due to twisting injuries these cartilages are frequently torn. The torn portions then lie more or less free in the joint or block the motion of the knee by jamming the condyle of one bone against the other, preventing motion. They must then be removed. If a satisfactory operation has been performed for a definite injury the resultant disability is comparatively minor, with rarely more than five to ten per cent loss of function. This disability is usually confined to a slight weakness of the quadriceps muscle sometimes referred to as quadriceps insufficiency. Motion is rarely restricted. If it does occur it is an indication of incomplete operation or other injury beside that of the cartilage.

Leg

General Prognosis. Fractures of the leg may be classified anatomically into three groups: (1) those that occur in the upper third of the leg and are associated with injuries to the knee joint; (2) those in the shaft of both bones; (3) those in the lower third of the leg about the ankle joint.

The shortening which follows fractures of the lower leg bears the same relation to muscle strain as shortening of the leg resulting from a fracture of the femur. Vicious union with angulation is a frequent sequel of fractures of the leg. Even a slight degree of angulation or displacement at the site of fracture may interfere with the static position of the leg producing strain and pain. Malalignment is more important than shortening in the lower leg. Atrophy is a common though temporary finding unless it accompanies marked displacement of the fracture. Pain as a sequel is due to soft callus or weakening of the musculature of the foot resulting in severe foot strain. In the former instance the pain is localized at the site of fracture while in weak foot the pain is generalized in the calf, ankle and foot. Edema (swelling) is an important complication of frac-
tures of the leg. The most frequent cause is venous stasis due to the prolonged horizontal position the patient has had to assume because of his disability. Stiffness of the joints that follows fractures of the shaft of the tibia occurs in the region adjacent to joints. Non-union is frequent. Next to fractures of the humerus, fractures of the lower third of the tibia are the most frequent site for delayed union and non-union. The poor blood supply is a contributory cause. The use of skeletal traction with prolonged distraction of the fragments is another cause.

Average Period of Incapacity. The period of temporary disability in fractures of the fibula alone in the average case should be seven to eight weeks. For fractures of both bones the period should extend to twelve weeks. Fracture of the tibia alone requires ten weeks.

Permanent Disability. The end results as they are manifested in the state of function of the lower extremity are measured in terms of loss of motion, muscular strength, loss of coordination and weight bearing. The following estimates were made in a series of two hundred eighty-six cases.

Fractures of Fibula

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Fractures of Tibia

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Fractures of Tibia and Fibula

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Ankle

**General Prognosis.** The prognosis depends not only upon the type of fracture and the kind of treatment but to a large extent on the age of the individual. Displacement of the foot as a result of fracture produces weak foot and static strain of the entire extremity. Edema is a common sequel. Pain is another common feature. Atrophy of the calf muscle is not severe. Bone atrophy (sudek's atrophy) is found especially after fractures of the ankle and is the cause of severe and prolonged disability. Stiffness of the ankle joint varies according to the actual involvement of the ankle joint by the fracture. Where the fracture has not entered the ankle joint the stiffness gradually disappears. The most common sequel is weak foot. This is due to the displacement of the foot as the result of the malalignment of the fracture or to the flabby state of the musculature from disuse and inactivity.

**Average Period of Incapacity.** The most important function of the lower extremity is weight bearing. If pain, weakness or other factors impair this function the patient is unable to return to work. Almost all occupations require a moderate amount of standing or walking.

The average period of temporary disability is two to three months, in the complicated case, four to five months, and in the very severe case, seven to eight months.

**Permanent Disability.** The estimate of disability should be made on the functional end result and not on the structural condition as disclosed by the X-ray. The deformity as revealed by the X-ray does not always bear a direct relationship to the disability. In a series of three hundred eighty-seven fractures of the ankle the following were the estimates allowed.

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**Foot**

**Weak Foot.** The foot is a remarkable mechanism. Adapted to support the weight of the body as well as propel it in walking,
running and climbing, it performs its functions in the routine pursuits of life with little thought or attention. Throughout the stress and strain of life, in the occupations as in all forms of social activity, it makes its adjustments automatically. When the limit of this adjustability is reached, the foot will break down like an elastic band that has been stretched too far. When this occurs, a condition of strain follows. This is attended by spasm of the muscles, pain, limitation of motion and other symptoms typical of foot weakness. The mechanical action of the foot is different in standing and walking. The muscles of the feet bear the brunt of the weight strain in walking; the ligaments take this strain in the standing, weight bearing position.

Fractures

**General Prognosis.** The foot is composed of twelve different bones, namely, the os calcis, the astragalus, the scaphoid, the cuboid, the three cuneiforms and the five metatarsals. Because of the multiple articulations, fractures of one intimately affect the structure and function of the others. They all contribute to the function of the foot in running, walking, climbing, jumping. The integrity of the arches of the foot is seriously impaired by fracture. The traumatic flat foot which results causes a functional disability which is more protracted than the weak foot due to muscular imbalance following a fracture in the lower leg, or that due to inactivity and strain.

**Astragalus**

**General Prognosis.** The fracture generally results in damage to the joint surfaces with interference with the motion of the various joints of which the astragalus forms a part.

**Average Period of Incapacity.** The average period ranges from three to six months.

**Permanent Disability.** Because the astragalus articulates with the tibia and fibula permanent restriction of motion of the ankle joint is the most common sequel. Weak foot is the next most important after effect of fracture. In a series of forty-six fractures, the disability ranged from twenty to one hundred per cent with an average disability of forty per cent.

**Os Calcis**

**General Prognosis.** This is the most disabling fracture of the foot. There may be a simple fracture of the posterior portion due
to a pull of the tendon Achilles since the latter is attached to the posterior fragment. The most serious fracture is the compression fracture caused by a fall from a height. The deformity consists of an outward deviation and a shortening of the bone from a push upward. In addition, the subastragalar joint between the astragalus and the os calcis is usually disorganized. When the fracture is comminuted (shattered into small fragments) reduction is never complete because it is difficult to secure a perfect anatomical restoration.

**Average Period of Incapacity.** The disability period varies from three to four months in the average case to eight to twelve months in the more severe cases.

**Permanent Disability.** The disability is due to a combination of factors. The breaking down of the longitudinal arch is only one of the causes for pain and disability. The involvement of the subastragalar joint is one which leads eventually to a disintegration of the joint with changes that can be best included under the general term of arthritis. It is frequently necessary to obliterate the joint by fusing the os calcis and astragalus by operation or arthrodesis. Due to the tremendous force usually involved in the production of this fracture of the os calcis, it is occasionally accompanied by fractures of the spinal column. These spinal fractures are occasionally overlooked because of the more immediate pain and disability suffered by the os calcis involvement.

In a series of one hundred seventy-one fractures the disability varied from twenty-five to one hundred per cent with an average of fifty per cent.

**Scaphoid**

**General Prognosis.** These fractures are difficult to reduce. They are usually caused by a fall on the ball of the foot with the foot bent down. Motions of inversion and eversion of the foot take place between the scaphoid and astragalus and may be limited by fracture.

**Average Period of Disability.** Although fractures of the scaphoid may be followed by the same sequelae as fractures of other bones of the foot, the disability as a rule is not so severe nor is the convalescent period long. The average period is six to eight weeks.

**Permanent Disability.** Weak foot is the most important functional end result. The deformity from an unreduced fracture may
be marked with only a minor functional impairment. In eighteen cases the disability ranged from ten to thirty-three per cent.

**Fractures of the Cuboid, Cuneiform, and Sesamoid**

**General Prognosis.** Fractures of these bones are perhaps less common than fractures of the scaphoid. Fractures of the cuneiform are complicated by traumatic weak foot since the cuneiform and the cuboid contribute to the support of the plantar arch. Fractures of the sesamoid rarely give any disability. These small bones lie in the tendons around the great toe and provide pulley-like action to these tendons.

**Average Period of Incapacity.** This period varies according to the number and type of fractures.

**Permanent Disability.** Fractures of the cuboid were allowed a disability ranging from ten to twenty-five per cent. Fracture of the cuneiform were given a similar estimate.

**Metatarsals**

**General Prognosis.** Fractures of the metatarsals are more frequent than is commonly supposed. The X-ray reveals a great number among patients who are regarded as malingerers. They are usually multiple and may also be associated with fractures of the tarsal bones and the phalanges. The most frequently injured bone is the fifth metatarsal.

The chief complication is flattening of the anterior metatarsal arch. If this arch is preserved and the correct weight bearing lines are maintained, the functional disability will be slight. As a rule, the displacement is not very great since the unfractured metatarsals act as a splint to those that are fractured.

**Average Period of Incapacity.** Sufficient time should be allowed for bony union before full weight bearing is permitted. Two to four months is the average period of temporary disability.

**Permanent Disability.** Depression of the anterior arch plays a very important role in the incapacity. Edema, weak foot and circulatory disturbances are the sequelae which interfere with function. In a series of ninety-eight cases the disability varied from five to fifty per cent with an average of fifteen per cent.
Toes

Single fractures are comparatively unimportant but multiple fractures of the toes are generally complicated by soft tissue injury as well. This may be a more disabling factor than the bony injury. In fractures of the great toe the temporary disability should last from four to six weeks. There are some instances where the individual will lose no time. Much will depend on the location of the fracture. If it is near the metatarso-phalangeal joint the disability increases since this is one of the major weight bearing points in the foot. In the same way embarrassment of the second weight bearing point in the region of the fifth metatarso-phalangeal joint may also produce marked disability. In fractures of the other toes the average period of disability will be three to four weeks. Individual temperament and the extent of soft tissue injury are additional conditioning factors.

Permanent Disability. There is an exceedingly wide range of variation in the permanent disability following fractures of the toes. Single fractures heal with very little disability. Multiple fractures do likewise unless they involve the anterior arch at the weight bearing points. In a series of three hundred twelve cases of the great toe the disability ranged from five to one hundred per cent with an average of forty per cent. In an additional series of four hundred two cases of fractures of the other toes the disability ranged from fifty to one hundred per cent with an average of ten to twenty per cent. These percentages are in terms of the function of the toe and not of the foot.

Peripheral Nerve Injuries

Nerve injuries in the lower extremity in civil life are extremely uncommon as a result of accidental injuries. Rarely are these nerves injured by direct trauma alone since they are fairly well protected by the deep musculature. Injuries to these nerves may occur as a complication of fracture when a sharp fragment splinters off and impinges on the nerve, or as a result of deep puncture wounds.

Lumbosacral Plexus

Injury to the lumbosacral plexus is exceedingly rare. Being deep seated and protected by the bony parts of the pelvis, its location affords sufficient protection from injury. However, injury to the sacro-iliac joint may set up a series of symptoms suggesting an
irritating lesion of the plexus. Since the sacro-iliac joint is supplied by the first and second sacral nerves, pain in the distribution of these nerves following injury may be confused with injuries to the plexus. This pain however is reflex or referred and is not to be construed as a symptom of lumbosacral plexus injury.

Sciatic Nerve

The sciatic nerve is the largest nerve in the body. It appears in the thigh at the sacrosciatic notch, pierces the pyriformis muscle and runs down the posterior aspect of the thigh to the popliteal region, where it splits into its primary divisions, the tibial nerve and the peroneal.

Injury to the sciatic nerve causes a paralysis of all the muscles below the knee and a paralysis of the internal hamstrings, biceps, and adductor magnus. It is uncommon however to see such a total lesion. The partial lesions are more frequent. A scattered lesion where the muscles innervated by the tibial and peroneal nerves escape involvement is also more common. Sensory and reflex changes also may vary considerably. In the case of a total lesion there is a marked atrophy of the entire leg and thigh, with trophic and sensory changes, resulting in a typical steppage gait in walking.

Average Period of Incapacity. The recovery period will vary according to the nature and extent of the lesion. Total lesions have an unfavorable prognosis. Eighteen months are required for recovery of the nerve following injury (severance).

Permanent Disability. Even with a total lesion the individual is still able to bear weight on his leg, so that complete disability is not present. This is due to the fact that the sciatic nerve does not supply the extensor muscles of the thigh upon which rests the task of stabilizing the hip. However in a total lesion of this nerve the disability is severe enough to warrant a disability of sixty-six per cent. In partial lesions this estimate would be reduced in accordance with the function of the muscles remaining. These estimates average twenty-five per cent.

Peroneal Nerve

The peroneal nerve is the most frequently injured nerve in the lower extremity because of its exposed location as it encircles the head of the fibula. The nature of the paralysis is analogous to that of the musculo-spiral nerve in the upper extremity. Similarly, the
prognosis is also good. The typical result of injury is a paralysis of the anterior tibial group of muscles with the characteristic drop foot and steppage gait.

*Average Period of Incapacity.* Although recovery is good, a minimum period of eight months is required. This may be protracted to fourteen months in complicated cases.

*Permanent Disability.* The disability is based on the condition of the foot without the aid of special shoes or apparatus. With prosthesis the disability is small. Without prosthesis an average disability of twenty-five per cent exists. Weight bearing is not affected as much as motion and coordination.

**Tibial Nerve**

The tibial nerve is not as frequently injured as the peroneal nerve. A lesion of this nerve causes a paralysis of the posterior leg muscles as well as all the plantar muscles. In walking the patient is unable to lift his heel from the ground and cannot raise himself on the tips of his toes.

*Average Period of Incapacity.* The minimum is six months, the maximum one year.

*Permanent Disability.* The disability in a tibial nerve paralysis is more severe than in a peroneal nerve paralysis. The permanent disability should be estimated at forty per cent in a total lesion of the nerve. In the case of lesions of the posterior tibial nerve, which is a branch of the tibial nerve involving only the plantar muscles, the disability will depend upon the extent of the clawing deformity in the foot and may average twenty per cent. All the above percentages are interpreted in terms of the entire extremity on the basis of interference with the function of weight bearing alone or with function as expressed in motion, strength and coordination of the entire extremity.

**Anterior Crural Nerve**

Injuries to the anterior crural nerve are rare. The nerve is nevertheless of great importance since it innervates the anterior thigh muscles, those muscles which extend the leg and are most concerned with stabilization of the leg and hence weight bearing. Damage from a lesion of this nerve would be difficult to repair and if there is no return of function after eighteen months (temporary disability) an estimate of fifty to sixty per cent should be made.
Obturator Nerve

Injuries to the obturator nerve are even rarer than to the anterior crural nerve. The lesion causes a weakness or paralysis of the adductor muscle group and the gracilis muscle. Since the major function of the leg is not seriously impaired, only a short period of temporary disability is required, three to six months. Permanent disability rarely exceeds fifteen per cent of the leg.

Summary

The pathological and physiological processes following injury have been discussed in order to understand the part they play in producing incapacity. The general principles of evaluating this incapacity have been described and the role of function not only emphasized but defined in mathematical terms where possible. The application of these methods to the end results of injuries in the upper and lower extremity from a valuable guide in meeting the demands of law and medicine for equity and accuracy.

REFERENCES

Bence, Internal Derangements of the Knee, Division of Labor Standards Bulletin No. 10 (U. S. Dept. of Labor, 1937) 242-262.
Campbell, Operative Orthopedics (St. Louis, 1939).
Bolebiewski, Atlas and Epitome of Diseases Caused by Accidents (Philadelphia, 1900).
Griffiths, Injury and Incapacity (London, 1885).
Hauser, Diseases of the Foot (Philadelphia, 1939).
Steindler, Mechanics of Normal and Pathological Locomotion in Man (Springfield, 1935).
Watson-Jones, Fractures and other Bone and Joint Injuries (Edinburgh, 1940).