3.

LETTSOMIAN LECTURES

ON THE

PHYSICAL CONSTITUTION, DISEASES, AND FRACTURES OF BONES.

BY

JOHN BISHOP, F.R.S.,

FELLOW AND MEMBER OF COUNCIL OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND;

CONSULTING SURGEON TO THE NORTHERN DISPENSARY;

CORRESPONDING MEMBER OF THE MEDICAL AND CHIRURGICAL SOCIETIES OF BERLIN AND MADRID;

ETC. ETC.

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LETTSOMIAN LECTURES

On Surgery.

LECTURE I.

DISEASES OF THE BONES.

Physical properties of bone; elasticity and strength; influence of their organic and inorganic constituents. Theory of Dr. Stark examined and refuted. Flexibility of bones; rickets; mollities ossium; caries, or ulceration of bone; psoas abscess.

GENTLEMEN,—There is, perhaps, no subject of greater interest to the practical surgeon than that of the human skeleton, both in a state of health and disease. It is from these considerations that I have selected this branch of surgery for the Lettsomian Lectures on the present occasion. Within the space of a few years, great progress has been made in the pathology of the bones, which has been very greatly aided both by chemical and microscopical researches. As, however, the pathology of the bones, taken as a whole, presents far too wide a field to be compressed into the space of three lectures, I have selected such points as appear to me most worthy of interest.

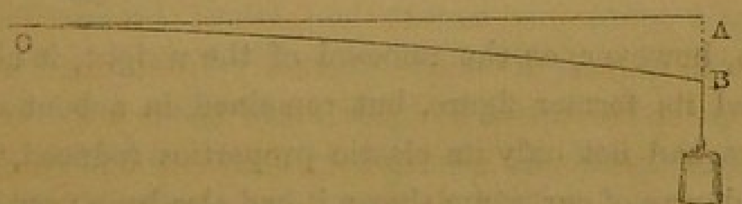
If we take into consideration the human skeleton with relation to its laws of formation, or its general conformation with reference to its several offices in the animal economy, we cannot avoid being struck with the perfection of its mechanism. In their normal condition, the bones have but little sensibility; but when inflamed, they become exquisitely sensitive. By the nature of their organization and nutrition they partake more or less of all the changes in health or disease that are incidental to the human constitution; they are, consequently, liable generally to many of the diseases by which the soft parts are affected, as well as to the special effects of mechanical violence. They are capable of being renewed in part when broken or destroyed by disease; and even the whole of a bone, under special circumstances, may be reproduced after the old bone has been removed As the skeleton is designed for the protection and support of the soft parts, it must necessarily possess certain mechanical and physical properties peculiar to bone. However, many of the physical characters of the bones are in common with those of inorganic bodies—such, for example, as rigidity or strength, and elasticity, brittleness, and pliability. As these physical properties exert a great and important influence in protecting and supporting, and in removing the body from one place to another, the changes that take place in these qualities must necessarily be of great interest to the practical surgeon, and more especially with respect to the theory and treatment of fractures and distortions. As these points have not yet received that consideration which they appear to merit, I propose in this lecture to enter more fully into this branch of the subject.

In a state of health, the bones appear admirably calculated, not only to protect and sustain the soft parts, but also to resist the shocks and pressures to which they are liable in the various occupations of the human family. If we contemplate the human skeleton as a piece of machinery destined to perform certain offices, and if we consider the number of its parts and the structure of the several kinds of joints by which it is held together, we at once perceive that it is designed and endowed to perform its functions with great precision, and that the full comprehension of its whole properties involves the most profound researches. The conditions which determine the form and structure of the skeleton, and the play of the vital forces in effecting its development, are problems of great obscurity connected and associated with the origin of man himself. During the development of the bones, from the period of infancy to old age, they are continually changing their chemical elements and physical properties. This is apparent both from physiological investigation and pathological research. Let us now turn our attention to those physical changes which the bones suffer in consequence of variations in the proportion of their organic and inorganic constituents; and, in the first place, let us investigate in what manner the elasticity and strength of bones vary contemporaneously with their chemical differences. By *elasticity*, in physics, is meant the property which bodies possess of recovering their primitive form and dimensions after the external force by which they have been extended, compressed, or bent is withdrawn; and *strength* is understood to mean the resistance offered by bone, or by any other solid body, to a force directed to break or fracture it. It is these two physical properties just defined which confer on the bones their capability of performing their offices. Both the elastic and rigid properties are often severely tested by the action of powerful muscles, and we know they are sometimes overcome by external violence, so that fractures ensue.

It will be proved, as I proceed, that it is the inorganic matter of the bones which confers on them their elasticity and strength, and the organic constituents which confer on them their cohesive properties and flexibility; this is apparent, inasmuch as if we take away the inorganic portions, the organic portions become inelastic, and bend with their own weight. On the other hand, if we abstract the whole of the organic portions, the bone becomes brittle, will not bend, and falls to pieces with a very slight blow. From these circumstances we are led to conclude that, in the state of health, the bones must be so constituted that the proportions of the inorganic and organic matter are such as to confer on them the greatest possible amount of elasticity and strength. After a most extensive analysis of the components of bone, pursued through a large series of the animal kingdom, and consisting of no less than 232 experiments, Dr. Stark found that the mean proportion of the inorganic to the organic substances was as 66·09 : 33·91, or very nearly as 2 : 1, and both Dr. Stark and Von Bibra found that the proportion of inorganic and organic matter is nearly the same in the bones of all the classes of mammalia; but as there are great differences in their hardness, Dr. Stark concludes that the hardness and strength of bones do not depend on the differences in the proportions of their earthy constituents, but simply on the differences in the organic structure of the bones. He further states that there is no difference between the earthy and the organic constituents of the several portions of the skeleton, and that the spongy portions of bone do not differ in chemical composition from the solid portions; but a mere glance at the tables will show the fallacy of these assertions.

It will be seen that there is a considerable difference between the laminated and spongy structures; and also that, according to the latest researches and the best chemical authorities, there are very sensible differences in the composition of different portions of the skeleton. Mr. Stanley and Mr. Paget seem also to have been misled by Dr. Stark; for they both concur in his views, and state, after him, that the strength of bones depends on their structure, and not on the quantity of earthy matter entering into their composition. These views, however, appeared so entirely at variance with our preconceived notions of the mechanical effects of the composition of bone, that I determined to test the truth of these assumptions; and this appeared the more necessary from their practical bearing on the treatment of affections of the bones. In order, therefore, to determine whether the elasticity and strength of bone really do, or do not vary, when the chemical components vary, and (if such be the case) what really is the smallest quantity of inorganic matter consistent with the efficient strength and elasticity of bone to protect and support the body, it is only necessary to remove by degrees from a lamina of a given weight of healthy bone, certain quantities of its inorganic constituents by means of dilute hydrochloric acid, and then to fix one end of the lamina firmly, and suspend at the other end a given weight, sufficient to bend it into a curve; having then measured the degree of curvature, if the elasticity is unimpaired, the bone will, as soon as the weight is removed, return to its primitive form. This process may be had recourse to a second, third, or greater number of times, and the elasticity estimated by the degree of curvature produced in each case with the same weight. It must be obvious, even to those who are unacquainted with the mechanical details of the strength and elasticity of bodies in general, that the body which is most bent under the same weight, (all other things being the same,) must be the weakest. With the object before-mentioned in view, I selected a rectangular plate of bone cut by a circular saw from the shaft of the femur of an ox, and after having carefully weighed the portion of the bone, its weight was found to be seventy-six grains. One end of it was then fixed firmly in a vice, a string was passed over the other end, to which a weight equal to 14,815 grains, or 2·11643 pounds, was suspended. It was allowed to remain in this state several days, when, on the weight being removed, the bone immediately recovered its primitive form, showing that its elasticity was unimpaired. The curve it made under the weight is seen in Fig. 1. The same bone was then plunged

FIG. 1.

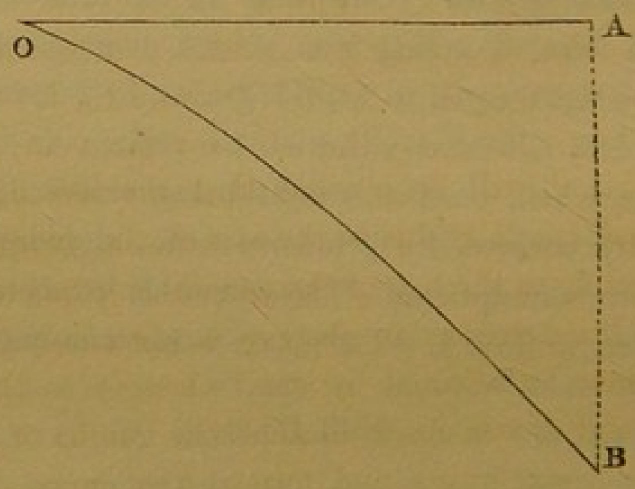


into a weak solution of hydrochloric acid. After remaining about two hours, it was taken out of the solution, and suffered to become dry; it was then again weighed, and was found to have lost 15 grains of its inorganic materials, thus reducing the weight of bone from 76 to 61 grains. The bone when dried was then again fixed, and the same weight being applied as before, the curve it then formed is seen in Fig. 2. On the

Fig. 2.

weight being removed, the bone in a few seconds resumed its original form, showing that it still retained its elasticity. The bone was again put into the acid, and suffered to remain a short time, when it was taken out, dried, and weighed as before. It was now found to have lost five grains more of its mineral components, the weight being reduced from 61 grains to 56 grains. On being again fixed, and the same weight applied, it bent into the curve as seen in Fig. 3. On this

Fig. 3.



occasion, however, on the removal of the weight, it no longer recovered its former figure, but remained in a bent state; it therefore had not only its elastic properties reduced, but the greater degree of curvature shows it had also been very sensibly impaired in strength; and as the proportion of the animal to the earthy matter, when the bone had its elasticity so far diminished, was very nearly as 2 : 3, we may consider this proportion as indicating the amount of deficiency of earthy matter, such as will render a bone, if distorted by pressure, incapable of returning to its primitive form. But, as it might be supposed by some persons that the loss of strength was due simply to the loss of material, and not to the chemical difference between the earthy and organic components of the bones, a similar rectangular piece was cut from the same bone, and ground down to precisely the same weight as the bone that had been acted on chemically, when they severally formed, under the same weight, the curves seen in Figs. 4, 5.

FIG. 4.

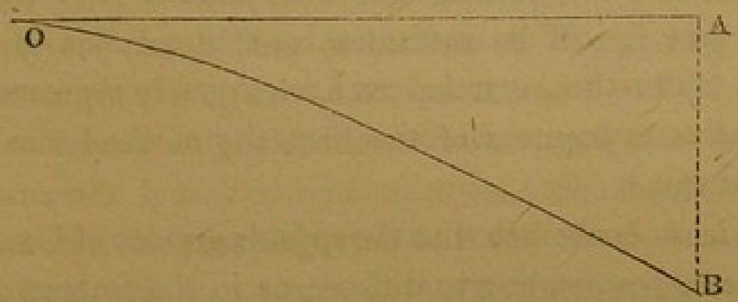
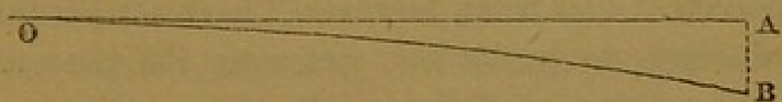


FIG. 5.



From this it will be obvious that the loss of strength is entirely and specially due to the loss of the inorganic matter, and not simply to the loss of the general substance of the bone. It is not a little curious to observe how sensibly the elasticity of bones may be affected by small changes in their chemical relations, and it was observed that the lamina of bone, which weighed fifty-six grains, and formed the curve already mentioned, (fig. 3,) had, after the lapse of several days, become drier, and on being again weighed it was found to have sustained a further loss of 2·5 grains, the waste being now of the animal matter. On being subjected to the same weight, it made the curve seen in fig. 4, which, when compared with the curve it formerly made, (fig. 3,) shows how small a difference in the components will alter sensibly its mechanical properties. However, this increase of elasticity by drying is not peculiar to bones, for Mr. Hodgkinson found that the strength and elasticity of many kinds of wood are greatly augmented by drying. In the process of preparing bones for mechanical and chemical experiments, it is usual to strip off the periosteum, and remove the fat; the oily matter will then pass off by drying, after which no very great difference will take place in the chemical properties of bone, even after the lapse of centuries. In order rigidly to compute the elasticity of any body by means of the curve it forms when it is bent in the manner now under consideration, would require a mode of analysis which it would be quite impossible to explain in a lecture; but it will be sufficient on this occasion to take the line (A B) in the several curves as inversely representing the comparative differences of the elasticity of the bones in their several states.*

There is no doubt but that the specific gravity of bones differs in degrees corresponding to differences in the amount of their components, and also that the elasticity varies according to the specific gravity. This point, however, I have not yet investigated sufficiently to justify my occupying the time of the Society with a statement of the result. Care, however, must be taken not to substitute the *strength* of the bones as if it were identical with their *elasticity*, inasmuch as these properties

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* In these figures—
O is the point of the origin of the curve.
O A is the tangent.
O B is the curve made by the bone.
A B is the measure of the elasticity.

The line A B in the figures represents only the comparative elasticity of the bones in the several curves; but the actual amount of elasticity may be obtained by the following simple formula:—

$$E = \frac{w\, l^3}{k\, b\, d^3}$$

And if we designate the strength by S, then

$$S = \frac{l\, w}{b\, d^2}$$

In which—
E is the elasticity.
k „ measure of the line A B.
w „ weight in pounds.
b „ breadth } in inches.
d „ depth } in inches.
l „ length } in inches.

are very disproportionate to one another in some bodies, some of the most elastic substances, such as glass, for example, being as we well know, very brittle.

The strength of bones, then, is a most important property belonging to their structure, and is essentially necessary for the healthy performance of the functions of the human system. It has been already seen how much the *elasticity* of bone depends on its chemical composition; and the same is also true with respect to the *strength*, as may be inferred from the curve made with the same weights, to which I have already invited attention. As there seems to be nearly a constant proportion in the components of bone in the health and vigour of life throughout the orders of mammalia, and as this proportion is very nearly as 2 to 1, between the inorganic and the organic materials, it may be concluded that this relation is the one which confers the greatest strength consistent with the functions the bones have to perform. The force necessary to crush a piece of solid bone is very great. According to the researches of Professor Robison, it is twice as great as with oak; and as the latter requires, according to Professor Hodgkinson, from 6484 to 10,058 lbs., we can easily imagine the immense weight it must require to crush bone. It has been remarked by Von Bibra, that those bones which are subjected to the greatest action have the largest proportion of earthy constituents. We find the same thing occurring in the enamel of the teeth, in which, in order to fit them for their offices, the proportion of the earthy phosphates is very large.

Enamel.

Inorganic ... ... =	98
Organic ... ... =	2
	100

Independently of the excess of phosphate and carbonate of lime, there is also found a small quantity of the fluoride of calcium, and to its presence Lehmann ascribes the fine polish and extraordinary hardness of the enamel.

Though the structure of ivory is very different from that of bone, yet it contains nearly the same chemical components. The strength and elasticity of these two substances appear nearly equal, as may be seen in the similarity of the curves they make when bent by equal weights (Figs. 6, 7.) Besides

Fig. 6. (Ivory.)

Fig. 7. (Bone.)

the difference arising from chemical composition, there is great difference in the strength of bones according as they vary in their form. The flat bones—such as the cranial and scapular for example: the former of which are expanded into discs for forming the dome of the skull; and the latter presenting an extensive surface for the attachment of muscles—are not so strong as the more solid forms of the bodies of the lower vertebræ: and, again, the cylindrical bones of the extremities are much stronger, on account of their being hollow instead of solid cylinders; for it is found, that with the same quantity of matter strength may be doubled, by the interior diameter of the tube being to the exterior as 100 : 71·66. In many parts of the skeleton considerable differences exist in the proportion of the constituents of the compact, the cancellated, and the spongy portions of the bones; and it must be manifest that the cancellated and spongy tissues are not adapted to confer on the bones as much strength and elasticity as the laminated structure; yet they perform several important physical offices. In the solid bones, such as the bodies of the vertebræ, the tarsal, and carpal, the spongy portions prevail, and give extension to the surface, without adding too much weight.

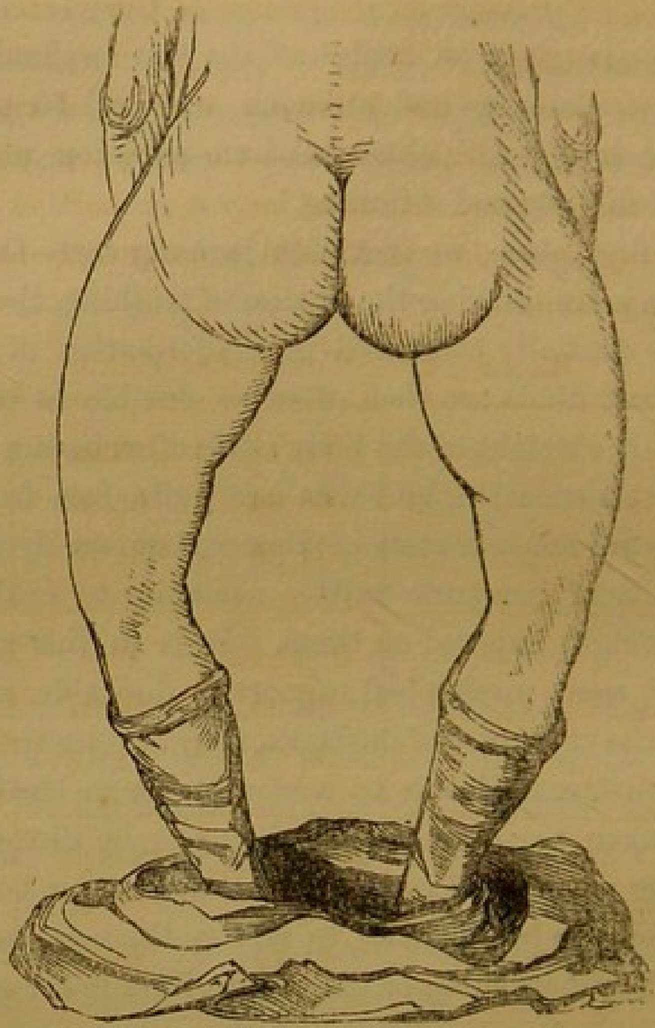
The ethmoid plates being very thin, are composed entirely of laminæ.

Having now given an outline of the two mechanical properties of bone, elasticity and strength, we shall be prepared to consider their opposite abnormal and pathological qualities—namely, flexibility and softening.

In the first place, we find that in early age—that is, from one to four years—during the process of teething, the phosphate of lime is partially consumed in the formation of the teeth. The tibia and fibula are then often so flexible as to be unable to support the weight of the body: this often occurs in children of healthy constitution, and who are quite free from rickets. The bones are not in a state of disease, but merely destitute of the quantity of inorganic matter necessary to enable them to bear the weight imposed on them. It is in this state of the bones that some mechanical support is desirable, inasmuch as if, during the curvature of the bones, they acquire the proportion of earthy matter sufficient to confer on them the elastic property common to normal bone, they remain distorted during life, and no mechanical contrivance that can be borne by the patient seems to be adequate to restore the bone to its normal figure. The rehardening of the bones of the lower extremities, when there is no organic disease, appears to take place in children about the age of four years. That in a great number of children the bones regain their figure without the inter position of any support, there is no doubt; but that other children remain distorted through life we have every-day evidence. The annexed figure of a girl about seventeen years old is an illustration of a case in which the bones had regained their elasticity before the restoration of their figure, and no force that could be employed was sufficient to correct the distortion. (See Fig. 8.)

Other cases of a similar nature have been under my care, and have been attended with like results. Cases similar in their mechanical nature to these affections of the lower extremities occur later in life to the bones of the vertebral column, about

Fig. 8.



the age of puberty, and more frequently in the female sex. The vertebræ, from this period until they arrive at the age of twenty years, are, in many young persons of a delicate constitution, so soft and compressible, that if they are unequally pressed on for lengthened periods by placing the body in any peculiar attitude, they give way, and, being inelastic, do not recover their form; and if the attitude tending to alter the shape of the vertebræ continue until the bones regain their normal proportions of inorganic matter, the distortion of the spine will resist any treatment, and deformity is established for life. The period for attention to these cases, then, should never be neglected; but if the proper time of treatment is taken advantage of, these cases of distortions of the spine do not present much difficulty of cure; for it is very easy to remove the cause of the unequal pressure on the bodies of the vertebræ by correcting the attitude.

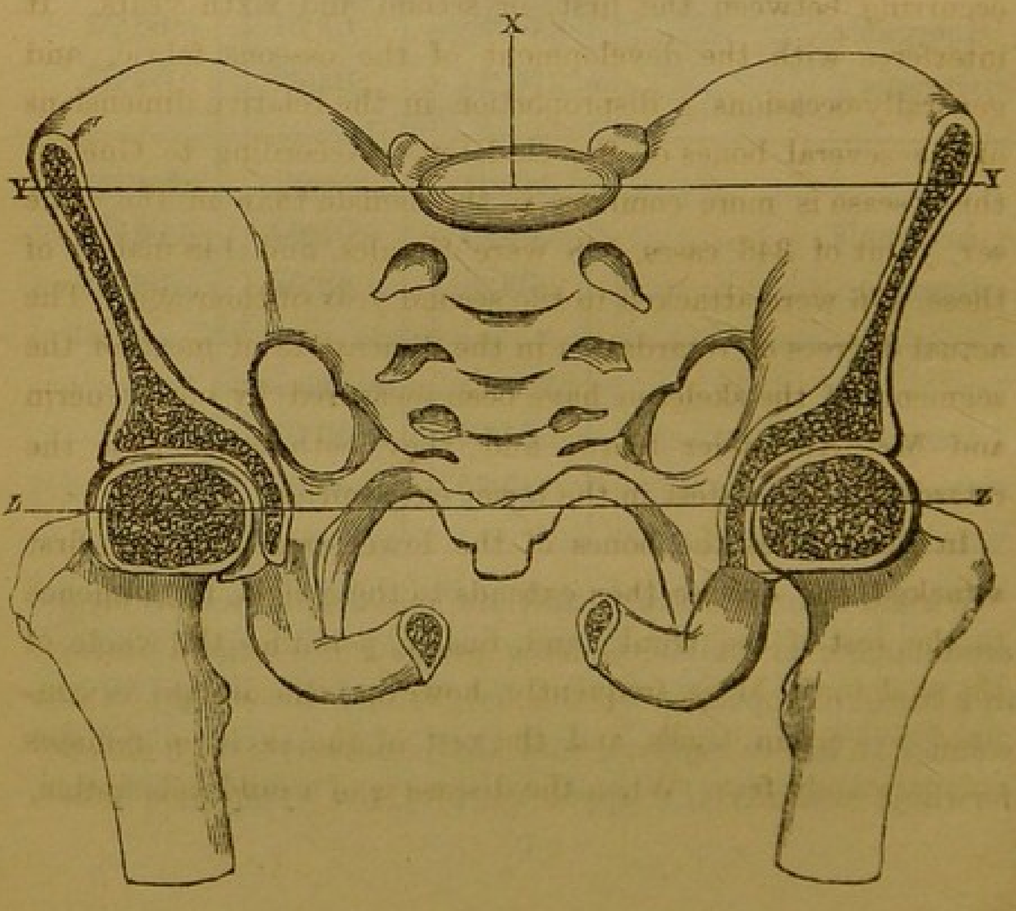
It will be seen by the following analysis of the bones by Von Bibra, that of all the bones of the skeleton, (the sternum excepted,) the vertebræ have the largest proportion of organic matter, being as 45·75 : 54·25, and consequently are the most easily compressible:—

Woman, aged Twenty-five Years.

	Femur.	Tibia.	Fibula.
Inorganic	68·64	68·42	68·54
Organic	31·36	31·58	31·46
	Humerus.	Ulna.	Radius.
Inorganic	69·25	68·87	68·68
Organic	30·75	31·13	31·32
	Metacarpus.	Clavicle.	Occipital.
Inorganic	68·88	67·51	68·73
Organic	31·12	32·49	31·27
	Costa.	Sternum.	Scapula.
Inorganic	63·57	51·43	65·38
Organic	35·43	48·57	34·63
	Vertebra.	Innominatum	
Inorganic	54·25	59·97	—
Organic	45·75	40·03	

We know, anatomically, that the spinal column rests on the sacro-lumbar articulation, which presents but a small surface, as a base, in proportion to the height and the weight of the column it has to support, and that, moreover, it is inclined forwards towards the upper edge of the symphysis pubis, at an angle of 30°, and it is obvious that the vertebral column must necessarily partake of all the movements and inclinations to which the base of support is subjected. The only position in which all the forces acting on the spine are in the state of the least action, is the erect position of the body; the sacro-lumbar articulation is then, on each side, at equal heights from the ground, and the vertebræ are equally pressed on by the superincumbent weights. In all other positions of the base of support, the vertebræ are subjected to unequal pressure, which, in the treatment of distortions of the spine resulting from mechanical causes, it is the great object to prevent. Any distortion of the legs, any unequal forces between them, or any difference in their extension in standing, all tend to give a lateral inclination to the sacro-lumbar articulation, and produce lateral curvatures of the spinal column. But in order to make this more apparent and incontrovertible, from the well-known structure of the pelvis, we may deduce that when the line Z Z, (fig. 9,) passing through the axes of the heads of the femurs, is

Fig. 9.



horizontal, the line Y Y, parallel to the surface of the sacro-lumbar articulation, will be also horizontal, and consequently the line in the direction of X, and in the mesial plane of the vertebral column must be vertical. From these considerations it is seen of how great consequence it is to the vertebral column to preserve the integrity of the figure and the force of the lower extremities at the period of life when the treatment is most effective.

The softening of the bones, which we have been considering, is that state in which there is no organic disease of the skeleton but merely a disproportion between the quantities of their organic and inorganic constituents, without any great degree of constitutional disturbance.

We now come to the consideration of those forms of softening of the bones which are attended with organic changes in their structure, and accompanied with great constitutional derangements. There are two forms of disease attended with softening of the bones—namely, rachitis and mollities ossium. Rickets is a disease affecting children at an early age, most commonly occurring between the first, or second and sixth years. It interferes with the development of the osseous fabric, and generally occasions a disproportion in the relative dimensions of the several bones of the skeleton. According to Guérin, this disease is more common in the female than in the male sex. Out of 346 cases, 198 were females, and 148 males; of these, 176 were attacked in the second year of their age. The actual degrees of retardation in the dimensions of most of the segments of the skeleton have been measured by both Guérin and Mr. Alexander Shaw, and they both agree that the retardation is greatest in the lower extremities.

In most cases the bones of the lower extremities are first attacked, the disease then extends to the pelvis, from thence to the rest of the trunk, and, finally, pervades the whole of the skeleton. More frequently, however, the disease is confined to certain bones, and the rest of the skeleton remains comparatively free. When the disease is of a mild description, the lower extremities and the metacarpal bones are those chiefly affected; the texture of the bones affected becomes sensibly changed, the Haversian canals and cells are enlarged, the cells of the spongy bone and the medullary canals become distended, and their walls are broken down and contribute to the formation of larger cavities. In process of time, the medullary cavities are expanded to enlarged areas, and the bones become soft and easily broken. According to Rokitansky, a pale yellowish-red jelly is effused into the canals, cells, and medullary cavities, and also penetrates beneath the periosteum. The inorganic constituents of the bones partially disappear, and the bone is reduced almost to its organic elements. The bone corpuscles are found empty, and their canaliculi disappear. In the lamellar structure, the lamellæ become partially obliterated, and between the remaining layers their vacant places may be easily seen under the microscope, the cavities being occupied only with occasional corpuscles which have fallen asunder. The bones in rickets become highly vascular, and the vessels gorged with blood, which is of a darker colour than natural. The periosteum also is more vascular than natural, and turbid; and it adheres to the bone so firmly that it cannot be torn from its surface without bringing away with it also a layer of the expanded spongy tissue. There is always found a considerable reduction of the inorganic constituents of the bones, as may be seen in the chemical relations in the table*, so that the bones are become soft and pliable, and have not sufficient strength to resist the action of the muscles. The tibia and fibula give way under the weight of the body, and curve in different planes; this is commonly the mechanical effect even in the milder cases of this disease; but in the more aggravated forms the pelvis is contracted, the vertebral column and ribs are

* *Proportions of the Inorganic and Organic Constituents in Rachitis, by Ragsky and Von Bibra.*

	Scapula and Humerus.	Ulna.
Inorganic	18·88	58·70
Organic	81·12	41·30

distorted, and the figure of the thorax is what is called pigeon-breasted. The disorganization of the bones most affected is so great that they never entirely recover their normal texture; but they may, however, in some degree recover their texture and form by the reabsorption of matter diffused into their cavities, and by the subsidence of the swelling of the bone; or the cure may be otherwise effected by the matter in the bones becoming firm, increasing in hardness, and at last ossifying. In the latter case, the bones remain hypertrophied, and become exceedingly dense and hard; the Haversian canals are contracted chiefly on the concave side of the curves, and the bones at these parts become not only hard, but elastic. It is at this juncture that the bones should be brought into their normal position—that is, before they become hard and elastic; otherwise they remain distorted through life, for the reasons that have been already explained. It might be easily supposed that a disease which produces such destructive changes in the osseous system cannot exist without great constitutional derangement. The pain, however, is not so great as might be expected from the degree of mischief inflicted.

According to Guérin, the time occupied in the incubation of rickets is about six months, during which a marked train of deranged action manifests itself. Many of these actions are common to other diseases; but some are peculiar, and determine the specific character of the complaint. The most ordinary symptoms are—gastro-intestinal irritation, accompanied with diarrhœa, enlarged abdomen, nocturnal sweats, mental depression, irritability of temper, weakness and emaciation of the muscular system, low febrile irritation, swellings of the bones of the extremities; the urine is loaded with the earthy phosphates; the countenance is pale; the face is attenuated, giving the appearance of increased age; the eyelids are usually wide open, the eyes brilliant, and with a lively expression; the nostrils are dilated; the lips kept apart; the skin is generally pale, and in some parts of a violet hue; the respiratory and circulating movements are accelerated; the appetite is feeble, and the digestion difficult. Such is the catalogue of constitutional derangements which accompany the organic changes in the bones already described.

The medical treatment of rickets is a subject of great interest, and it requires all the talents of the pathologist, and great tact in therapeutics, to arrest the progress of the disease, and bring the case to a successful issue; but with judicious treatment this complaint does not usually terminate fatally.

The other form of softening of the bones—namely, osteomalacia, or mollities ossium—occurs at an adult period of life, and frequently at very advanced age. This disease differs from rickets with respect to the effects produced on the bones, and also (according to the present state of our knowledge) with regard to the susceptibility of cure. It is also, fortunately, compared with the frequency of rickets, a very rare disease. It attacks chiefly the bones of the trunk, leaving the rest of the skeleton comparatively free, and happens to invalids already bed-ridden, which circumstance tends to give rise to the distortions peculiar to this complaint. When the bones of the extremities or of the skull are affected, they do not suffer so much as the trunk. It occurs more frequently in the female than in the male sex, and is often associated with cancer.

The effect of this disease on the bones is of the most fatal character, and, besides being malignant, it is very painful. The change in the bones first commences in the laminæ, which increase in size; and the bones around them become more transparent, and finally, several laminæ unite and form one cavity. However, this cavity does not long remain empty, but (according to Professor Quekett) becomes filled up with a kind of soft adipose tissue, so that the bones are found attenuated, and full of fat. From this latter ultimate condition, the disease has been classed with those of fatty degenerations. In other cases, the absorption of the earthy matter is so great that the bones are reduced almost to their cartilaginous state; they become flexible and often brittle, and may be easily cut with a knife.

Proportions of Inorganic and Organic Constituents in Osteo-Malacia.

(By Bogner.)

	Scapula.	Radius.	Femur.
Inorganic	34·15	36·58	30·23
Organic	65·85	63·42	69·77

(By Von Bibra.)

——	Man, aged 60.	Woman, aged 75.	Woman, aged 83.
	Vertebra.	Vertebra.	Costa.
Inorganic	20·25	20·10	38·66
Organic	79·75	79·90	61·34

Independently of the substitution of fat for osseous tissue, in mollities ossium, there are sometimes found imbedded in the deposit peculiar nucleated cells, which are probably malignant. The distortion of the skeleton in these cases often becomes of the most irremediable and frightful description. The pathological state of the body that produces these effects on the bones does not appear to have been very accurately described, or even investigated; but the case detailed by Dr. Bence Jones shows that the kidneys secreted a large amount of the earthy phosphates, together with 66·97 in 1000 parts of a peculiar substance, which was found by ultimate analysis to consist of a hydrated deutoxide of albumen; and hence Dr. Jones concludes that, as far as the albumen is concerned, each ounce of urine was equivalent to an ounce of blood lost. On examination after death, the kidneys were found healthy, nor could any structural derangement be discovered by the microscope. Dr. Jones recommends that this substance should be again sought for in acute cases of mollities ossium; and also if chlorine be present in the urine, of which there was a suspicion in this case, as he thinks that it might lead not only to the explanation of the formation of the albuminous substance, but also to the comprehension of the nature of the disease by which the bones are thus affected. Lehmann imagines that the deposition of fat in the bones is an effort of the *vis medicatrix naturæ* to impart some matter to supply the place of that which has been removed by the disease.

In the case examined by Dalrymple, he states that the quantity of matter deposited in the lumbar vertebræ was not equal to that removed by absorption, and that the thickness of the bodies scarcely exceeded that of the inter-vertebral substance; and these vertebræ had lost nearly one-third of their normal bulk. It would appear from the morbid anatomy of the specimens of the bones affected with this disease preserved in this country, and from the researches of Rokitansky, that the deposition of fat in the bones is most common in England, and the degeneration of the bones to a cartilaginous state in France and Germany; and that, while the disease in the former country affects chiefly the extremities, in the latter it may affect the whole or any part of the skeleton.

The next subject to which I propose to engage your attention, is that of ulceration of bone. We find that the substance of bones, like that of the soft parts, is liable to ulcerate, and this, indeed, is a very common form of disease to which the osseous system is liable. The most familiar example of ulceration of bone is that of caries. This may follow from a simple inflammatory state of the osseous tissues, arising from blows or shocks of the system, but it is more frequently the result of some taint of the constitution, such as scrofula, or syphilis. Sometimes caries is associated with morbid growths of a malignant character, such as tubercle or cancer. Caries is most commonly situated at the surface of bones, and attacks the compact tissue; but at other times it commences in the interior of the bone, and in the medullary portion. It may affect only a small portion of a bone, or the whole extent, such as the bodies of one or several of the vertebræ, or the tarsal or carpal bones, or that of a whole finger or toe. It sometimes presents a circumscribed spot on the shaft of a long bone, or on the superficies of the bones of the head; in fact, there are no bones in the skeleton exempt from liability to the attacks of caries. The bones, in a state of ulceration, present many different aspects, depending on the cause and the state of the constitution under which it is produced; and the treatment must be governed in a great measure by the constitutional affection which gives origin to the disease, as it is apparent that in syphilis and in scrofulous affections the treatment will correspond accordingly. When the caries is seated in the compact tissue, the bone is found covered with an ichor, and presents a rough and irregular surface; this aspect is produced by the unequal action of the disease on the parts affected; the Haversian canals become enlarged, and the surrounding parts disorganized and infiltrated with ichor; granulations of a spongy texture, which easily bleed, are generated from them; these granulations advance outwards on the rough surface of the bone, and internally they, in a greater or less extent, fill up the expanded Haversian canals. The bone in these cases becomes porous and discoloured, presenting various tints of red, from the colour of the granulations. When the cancellous tissue is the seat of the affection, the bone becomes of a red colour, soft, and brittle, or it may be easily cut with a knife, or yield to the pressure of the finger, and finally the bone becomes swollen, especially when the spongy bone is implicated, in consequence of the walls giving way to the pressure within. In the carious state of the internal portion of the bone, during the inflammation of the Haversian canals, a saneous product is effused, which causes a partial solution and loss of the osseous tissue; the canals are enlarged in every direction, and become filled with secreted matter, which, according to Delpech and several others, is composed of a peculiar fatty matter; but, according to Mouret, the gelatinous portion does not disappear, and this seems to be confirmed by chemical analysis.

Proportions of Inorganic and Organic Constituents in Caries.

(Valentin.)

—	Age 20. Vertebra.	Age 28. Tibia.	Age 38. Tibia.
Inorganic	45·17	54·38	44·12
Organic	54·83	45·62	55·88

(Von Bibra.)

—	Age 15. Nasal.	Age 40. Vertebra.
Inorganic	52·09	50·22
Organic	47·91	49·78

In this analysis of the bones in caries, it will be seen that there is an absorption, principally of inorganic matter, and that in some bones it is even less than that of the organic, so that they become compressible and inelastic; and hence the distortions which this disease may occasion. The acrid fatty matter is variously tinted, and will, as we know, blacken both silver probes and linen. It also contains small particles of bone, which are doubtless minute portions of the bone in a necrosed state, for in all forms of caries very minute particles of bone successively die, and are thrown off. Hence, by examining the pus, we can always form a diagnosis as to whether the bone is or is not in a state of ulceration by the presence or absence of bony particles. When macerated and dried, the carious bone is rough, and appears as if corroded and worm-eaten, the cells of the cancellous structure are enlarged, or its walls demolished, and the bone becomes lighter than natural, discoloured, expanded, and brittle. In some cases, the neighbouring bones are porous and hypertrophied, but terminating in atrophy of the bone. After the destructive process in caries has proceeded to a greater or less extent, the diseased state is changed into a healthy, suppurating, and granulating process. The deposition of new bone, however, is very limited, and, in the vertebræ, the loss of almost the entire bodies may result; and, indeed, when they are once destroyed they appear to be never entirely reproduced, as some orthopœdic authors have asserted, and great and incurable deformities of the body succeed. While the disease is going on, the surrounding soft parts are more or less inflamed, and the periosteum and ligamentous tissues adjoining are necessarily involved in the affection. The mode by which the ulcer of bone finds an opening externally is sometimes by a large abscess in the vicinity of the ulcer, sometimes by a tortuous fistulous opening at a considerable distance from the seat of the disease. When the pus is thrown off from the lumbar vertebræ in caries, it very frequently gravitates down into the thigh, below Poupart's ligament, where it forms a sac, which is well known under the term "psoas abscess;" sometimes the matter collects immediately under the femoral artery, and pushes the artery outwards, so that in placing the finger on the tumour, it is found to pulsate, and may be mistaken for aneurism. A correct diagnosis, however, may be obtained by ascertaining that the pulsation is not diffused over the surface of the tumour, but remains restricted to the line of the artery. There are always more or less constitutional derangements associated with caries. When the latter is occasioned by blows, or other extraneous causes, the constitutional disturbance will be sympathetic; on the contrary, when the disease in the bones is the result (instead of cause) of a pathological state of the system, the constitutional derangements are not only sympathetic, but primary. The predisposing conditions of the system such as those infected with scrofulous and syphilitic taints, which result in caries, are the most common, and are generally the most tractable when taken in time, and if appropriate treatment be applied; but why the bones should be selected to suffer in the manner they do, is not at present intelligible. But when the constitution is delicate, and the patient has not the means of obtaining those changes of air, diet, and medicine required, they frequently sink from the profuse discharge and exhaustion of the vital powers of the system. However, the constitutional derangements in caries are very different in various individuals, and the degree of irritation seems not always to depend on the amount of the loss of osseous tissue by the disease, inasmuch as in some persons a very small speck on a bone will give rise to great constitutional irritation and death, while in others, nearly the whole of the body of one or more vertebræ may be sloughed away without endangering the life of the individual.

It would be superfluous in these lectures to enter minutely into the details of the constitutional treatment of caries, when the nature of the taint in the constitution has been thoroughly understood, as that would lead to all that belongs to the pathology and treatment of syphilis, scrofula, and other predisposing affections; and it is necessary only to mention the great value of the mercurial and iodine salts in the constitutional taints to which I have just referred. Since the promulgation of the views of Lugol, on the influence of iodine in scrofula, I can bear testimony, from many years' experience, of the special value of combinations of iodine and iron in diseases of the bones when associated with a scrofulous constitution.

With regard to the surgical treatment of caries, it must be borne in mind, that the disease in the bones always begins in an inflammatory condition of its texture, and it may be either acute or chronic, but it is very frequently of a chronic character, of such a low type that the disease often runs into a state of ulceration before much attention is given to it by the patient; and in this case there is frequently so much delicacy of constitution as to forbid any depletory measures, and the issues, setons, moxas, cauteries, and blisters applied as counter-irritants over the parts affected, in many of these cases fail to produce the great relief expected from them. Still, in some cases they are said to be instrumental to the cure. In caries, (especially of the vertebral column,) rest is absolutely requisite, and pressure on the bones affected should, as much as possible, be removed; for this purpose, triple, inclined and prone planes, water and spring beds, and other mechanical apparatus, have been provided. Having already published my views of the comparative merits of these contrivances, it will be unnecessary at present to call your attention to that subject.*

With regard to the treatment of abscesses which are formed in cases of caries of the bones, much difference of opinion has prevailed. The question is, after the disease has been cured, whether an abscess, such as a psoas abscess, should be left to the efforts of nature, or be made the subject of surgical treatment. Sometimes the pus disappears spontaneously by absorption; at other times it will remain for several years without giving rise to any mischief. Occasionally the walls of the abscess give way, and the contents are discharged, and do not again accumulate; in other cases, the pus becomes, after a time, converted into fat. Dupuytren and many other surgeons maintain that it is highly dangerous to open abscesses resulting from caries, and that "it is preferable to leave them to nature, whether the caries yield to treatment or not." Mr. Abernethy and others, again, have recommended opening the abscess by a lancet, and healing the wound by the first intention immediately after having discharged the matter. It is always important to ascertain whether the disease in the vertebræ is still making progress or not, (which may be done in the manner already explained,) as it is obvious that the abscess would require bein repeatedly opened as long as the ulceration of the bone continues; but as long as the presence of the matter is productive of no constitutional irritation, it may perhaps be much better to let it alone, from the consideration that it has frequently happened that the health of patients has rapidly changed for the worse immediately after the operation.

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* See Researches into the Pathology and Treatment of Deformities in the Human Body, chap. xii.

LECTURE II.

DISEASES OF THE BONES.

On necrosis. Organic changes of the bones in this disease. Their origin hypothetical; mode of formation of the new, and of the throwing off of the dead bone. Necessity for the removal of the dead bone by surgical aid discussed. On exostosis, osteophytes, and soft tumours of bones. Difficulties of their diagnosis.

In my last lecture I pointed out that the strength and elasticity of bones depend on the proportions existing between their organic and inorganic constituents, and that when they are in a state of elasticity they are capable of resuming their normal figure, after being distorted by any force applied to them; but that when they are inelastic they remain distorted, and cannot recover their primitive form as long as they continue in that condition.

In the present lecture it is my intention to submit to your consideration the subject of some of the organic diseases of bone, including those of inflammation, necrosis, and exostosis.

Inflammation of Bone.

The bones, like all other tissues of the human body, are liable to inflammation. They possess a very low degree of sensibility in their normal state; but when inflamed they become exquisitely sensible. The causes of ostitis are numerous; it may be the result of external injuries, or of internal constitutional derangement. It is sometimes secondary, and the consequence of an inflammatory condition of the periosteum and surrounding soft tissues. The inflammation is sometimes of an acute, and sometimes of a chronic type; which states are determined by the nature of the circumstance by which it is produced. Amongst the most frequent of the external causes to which we may ascribe the inflammation of bones, are mechanical injuries, such as falls or blows; also sudden, or prolonged and excessive states of heat and cold. Sometimes the inflammation attacks the outer layer of the bone, and is then combined with periostitis; at other times it affects the inner surface, and is then combined with an inflamed state of the medullary membrane, or it may affect the whole thickness of the bone at the same time. The products of an inflamed bone are in many respects different from those of the softer tissues. In a moderate degree of inflammation of the external portion of a bone, the product consists of a gelatinous, dark-red exudation, which changes its colour to a reddish white, and finally becomes a pure white. Whilst these changes in colour are taking place, the gelatinous exudation, which coagulates like the white of an egg, is metamorphosed into soft flexible cartilage, and finally consolidates into reddish-white succulent bone. In this way the portion of the bone affected becomes covered, either with a thin porous film, or a thicker layer resembling velvet in its texture. The periosteum is swollen, and loosely connected with the exudation. When the exudation is in a more advanced stage, it becomes organized, and unites, forming the outer layer of the bone, to which the periosteum becomes firmly attached. When the internal lamina of a long bone is attacked with inflammation, the secretion is lodged on the internal surface of the medullary tube, or on the spongy substance, and consequently the medullary tube becomes contracted, and the spongy substance acquires greater solidity. Sometimes the exudation is deposited on the wall of the Haversian canals, and the bone becomes indurated. Independently of these products, there are others which are the results of inflammatory conditions of the bones. Some of these products become organized in different ways: some change into osseous structures, which differ from the texture and composition of healthy bone; others acquire a fibroid or cellular tissue.

These abnormal products are attended with an expansion of the bone, the amount of which depends on the quantity of matter secreted; and many of the cases of expansion of texture and increase of volume are due to these products of inflammation of the bones.

When the bone is affected with acute inflammation, the product is either of a fibrinous or of a purulent character, which varies in degree of fluidity in proportion to the greater or less quantity of serum which is contained in the effusion. It is also frequently tinged with blood, or with a brown or green-tinted sanies. In these acute forms of inflamed bone the periosteum is loosened from the bone by the fluid thrown off beneath it, and it then becomes distended into a fluctuating sac. The exudation is chiefly deposited in the cancellous structure; but some of it finds its way into the Haversian canals of the compact tissue. The surface of the bone becomes rough and eroded from the destructive solvent power of the effusion. The walls of the Haversian canals are similarly affected, and the cancellous structure shows more clearly the destructive nature of the effusion; the network becomes dull and opaque, and its membrane may be easily torn. This is a formidable condition of inflammation of bone, and may lead to the absorption of the purulent secretion into the system, and thus destroy life, or, if it take a more favourable turn, it may end in the death or necrosis of the bone.

When the spongy substance is the seat of inflammation, the pus thrown off is sometimes enclosed within the walls of the compact bone. This form of internal abscess of the bones often occurs in the shafts of the femur and tibia, and has been described by Sir Benjamin Brodie, Mr. Arnott, and Mr. Mayo. This abscess is generally attended with considerable and lasting pain, and often produces enlargement of the bone, accompanied with great constitutional irritation. The modern treatment of these interosseous abscesses is due to Sir Benjamin

Brodie, and consists in first making a crucial incision through the soft parts, and then perforating the bone with a middle sized trephine, penetrating through the compact into the cancellous structure; the membrane surrounding the abscess is then perforated to allow the pus to escape; the cavity is afterwards filled up by means of healthy granulations. The seat of these abscesses is almost always in the head or in the lower part of the tibia. It is known that the matter will remain many years without producing any necrosis of the bone, in consequence of the membrane by which it is surrounded protecting the bone from its effects. The diagnosis of the precise seat and nature of the collections of matter in bone is a subject of considerable difficulty, and it requires great tact to determine its pressure and locality; but the enlargement of the bone, and the persistence of pain in its internal part during a series of years, are the most prominent symptoms for our guidance in the treatment. But notwithstanding the difficulty of forming a correct diagnosis of the actual presence and special seat of an abscess in many of the bones, it is, nevertheless, very unwise to make experimental explorations and perforations in them, in order to obtain that knowledge, from the liability of these attempts to produce inflammation of the bone and sloughing of the soft parts—evils which are too serious in their consequences to warrant such proceedings without the most mature consideration. When the suppuration of the external laminated surface of a bone is confined to a small spot, the inflamed part of the bone exudes a product which is susceptible of ossification. It will be easily understood, from what has been said respecting inflammation of the bones, that various states or stages of inflammation are accompanied by variations in the nature of the product. The product also varies in different states of the same system, or in different constitutions. The treatment of inflammatory states of bone is conducted on the same general principles as those of the inflammatory conditions of the soft parts; but it should be borne in mind that active local depletory measures do not produce the same amount of beneficial effect so rapidly as may be accomplished in those tissues which are more accessible to local remedial agents. The interposition of the more highly vascular soft tissues tends to prevent the application of remedies immediately to the bone, and it is often only after the long-continued use of counter-irritants, applied on the adjacent soft parts, that chronic forms of inflammation of the bone subside.

In the acute forms of ostitis, active depletory measures must be early had recourse to, in consequence of the rapid changes the osseous tissues undergo while passing into the suppurative process. These measures may be aided by either warm fomentations or cold lotions, according as the nature of the case indicates. Mr. Stanley recommends mercurial ointment to be applied to the surrounding soft parts, and he states that the iodide of potassium, in doses of three grains, repeated three times a day, never fails to assist in the removal of inflammation of bone. It is obvious that absolute rest must be enjoined, and if the seat of the mischief is in the vertebral column, the recumbent position is indispensable. It would be superfluous to detain the Society by minute details of special cases, as on the present occasion it is only necessary to lay down general principles. Although bones die, and are thrown off by the vital energies of the system, particle by particle, as is the case in caries, the disease is essentially different from the complete death or mortification of large segments of bone, as happens in the disease included under the term necrosis.

In caries, the circulation of the blood, modified by the disease, is still going on; but in complete necrosis of bone, the circulation is entirely suspended. Whatever tends to interrupt the free circulation of the blood in bone, tends either to the atrophy or to the death of the part, as in the softer tissues of the body. From these conditions it is that we find that necrosis generally attacks those osseous tissues which are endowed with the least vascularity, and therefore the compact portions of bone are much more liable to this disease than the cancellous or spongy structures. It is apparently for this reason that the shafts of the cylindrical bones become affected, while the softer tissues at each end remain free. Indeed, we may state, in general terms, as an axiom, that the liability of a bone to spontaneous attacks of necrosis is inversely proportional to its normal vascularity. In corroboration of this view Kolliker* remarks, that "there can be no doubt that the fluids which the plasmatic vascular system of the bones receives from the bloodvessels, probably modified by the influence of the nucleus which is retained in every lacuna, are most indispensably requisite for the maintenance of the bone; for we see that when the supply of blood is impeded by the destruction of the periosteum of the medulla, by ligature of the vessels of the limb, or by the obliteration of the periosteum, necrosis of the bone certainly ensues." But independently of the causes already assigned, there are many others which may be enumerated tending to produce the death of bone : for example, if the bone receives a severe shock, or is crushed, or subjected to extremes of heat or cold. Necrosis may also be the result of internal constitutional causes, such as scrofula, syphilis, gout, and scurvy. In the organic changes which take place in the bone, it is found that, while in caries the earthy salts are diminished, in necrosis it is the organic matter that disappears.

NECROSIS.

Proportions of Inorganic and Organic Matter found in several cases in the Phalanges.

I.	
Inorganic	79·20
Organic	20·80
II.	
Inorganic	60·77
Organic	39·23
III.	
Inorganic	67·43
Organic	32·67

* Manual of Human Histology, p. 381.

There are not any bones in the whole skeleton that are not liable to be affected with necrosis. The whole of a bone may be affected, but this is not a common occurrence; for we generally find a segment only, of greater or less magnitude, involved; sometimes the outer lamellated portion is necrosed; in other cases the diploetic tissues. When the internal portion of a bone is affected, it is often confined to that portion of the bone; but sometimes the disease penetrates to unequal depths, and may even extend nearly through the lamellæ.

Experience has shown us that the least vascular portions of the bones are the most liable to be affected with this disease; we accordingly find that it affects the shafts of the long bones, such as the tibia, the femur, the humerus, the radius, the ulna, and also the bones of the skull, all belonging to the class of bones which possess a very low degree of vascularity. It is a disease that most frequently attacks young people, and more especially those of a scrofulous constitution, but it may occur at any period of life. The vascular spongy tissues which are the least liable to necrosis are, for the same reason, those most liable to be affected with caries.

When a portion of a bone becomes necrosed, it sets up an active state of inflammation in the healthy bone lying in contact with it; the inflammation goes on to suppuration, which is kept up until the dead bone is removed, either by the process set up by the system, or by surgical manipulation. But when the disease is left to the natural powers of the constitution to remove it, the exhaustion consequent on the profuse suppuration induced is often so great as to destroy the patient. The inflammatory state of the bone sets up an inflammation of the surrounding integuments, which ulcerate, and one or more sinuses are formed, through which the matter thrown off by the bone passes, including scales and particles of the sequestrum. The suppurative process is then the means provided by nature to separate the dead from the healthy bone, and to throw off the sequestrum.

It is easy to distinguish the dead from the healthy bone by its bleached, dull-looking, and discoloured appearance; but until a complete separation between them has taken place, it is difficult to determine very accurately their boundaries, in consequence of the blending of the colours of the dead and healthy bone with each other. According to Rokitansky—

"Around the dead bone, wherever it is in contact with the healthy bone, the latter undergoes a gradual expansion or rarefaction of its tissue by the enlargement of the Haversian canals; it assumes a rosy tint, and becomes succulent; the lamellated tissue gradually acquires an areolar structure, becomes more and more rarefied, and at length disappears altogether, and its place is occupied by the substitution of a red, soft, spongy substance. This change is effected by the inflammation which has been set up giving rise to suppuration and granulations. The bony tissue is dissolved by the matter secreted in the Haversian canals, while the granulations which are produced at the same time fill up the enlarged canals. The result of these processes is the production of a furrow which encircles the margin of the dead bone; this furrow is gradually filled up with granulations from the healthy bone as far as the surface of the dead bone, thus filling up the space which separates the living and the dead structure."

From this we see that the production of purulent matter for the removal of the dead bone, and the granulating process for the formation of the new bone, are being carried on at the same time; and Rokitansky is of opinion that these views of the processes are much more rational than those which assume that inflammation and absorption are employed simultaneously. Sometimes the granulations from the healthy bone will perforate the sequestrum where its segments are thinnest; and where this takes place in several points they may completely surround the dead bone, and fix it so as to delay its removal. The perforations are supposed to be effected by the corrosive quality of the matter acting on the tissue. This view seems strengthened by the fact, that independently of the irregularities on the surface of the sequestrum that give rise to the unequal thickness of the dead bone, the side that opposes the surface of the suppurating tissue appears rough and worm-eaten, and is discoloured, and often black. These views, which accord with the state in which the tissues present themselves in this disease, are nevertheless hypothetical, and require further investigation.

When necrosis takes place on the surface of the bone, the inflammation leads to an exudation which subsequently ossifies on its surface, immediately beneath the periosteum; and as these processes of inflammation and exudation extend inwards, they involve the whole thickness of the bone, and finally reach to the medullary canal, or to the spongy or diploetic tissue. The deposition of the new bone takes place in the internal part of the bone beneath the lamellæ, as well as on the surface of the bone. The exudation which takes place on the surface of the bone is sometimes very considerable, and the deposit goes on and enlarges the bone until it has acquired a considerable dimension. The suppression of the exudation depends in a great measure on the time occupied in the removal of the dead bone; so that it is obvious that the sooner the latter is accomplished, either by nature or art, the less will be the waste of the system. The granulations uniting with the cicatrix of the soft parts being thinner than the surrounding bone, a depressed scar is generally presented, lying in the hollow formed by the surrounding parts. The degree of depression of the scar depends on the thickness of the surrounding bone. In the reproduction of the new bone, the first deposit appears to take place around the Haversian canals in circular, radiating discs; at least this is the view taken by Professor Quekett.

It is a remarkable provision of nature, that the muscles, after remaining for some time connected with the dead bone, by passing through the openings in the new, gradually become detached from the necrosed part, and insert themselves in the new. When the necrosed bone is internal, the new osseous matter is exuded from the internal surface beneath the periosteum, the membrane adhering firmly to the inflamed soft parts surrounding the bone. When the internal necrosis occupies only a portion of the shaft of one of the long bones, the rest of the medullary canal becomes filled up with new bone. Sometimes the new encloses the dead bone, and forms a shell, which consists of two layers, one of old, and the other of newly-formed bone, lined with periosteum. This case is termed the sequestral capsule. This capsule is perforated by openings varying in size and number, which lead into the cavities of the sequestral capsule, either obliquely or directly. The openings are either of an oval or of a rounded form, and about the size of a bean or pea. Most of the openings communicate with abscesses in the soft parts, which open externally, either directly or by fistulous canals, taking a tortuous course, and opening at a distance from the aperture in the bone. When the fistulous openings are connected with the necrosis that has extended from within outwards, and penetrated the external laminæ of the bone, where no new bone has yet been deposited, the openings are lined with granulations, which are continuous with the inner membrane of the sequestral capsule. The pus continues to be poured out as long as the dead bone remains; but it ceases when the entire removal of the sequestrum is accomplished. The existence of osseous granules in the pus is a sure means of ascertaining whether the disease of the bone is, or is not, going on. The process of ossification then succeeds, and the medullary tube is filled with a solid cylinder of bone. After the lapse of some time, a gradual enlargement of the Haversian canals of the newly-formed bone takes place; the canals change their organic structure, and instead of being osseous, become of a cellular structure, which is supposed to perform, though imperfectly, the functions of a medullary canal. When the process of regeneration has been completed, the bone is composed of the internal cylinder of new bone, surrounded by a case of the old bone, and an external layer exuded beneath the periosteum. For some time there is a well-marked boundary between the old and the external layer of new bone, but ultimately this becomes undistinguishable.

The surface of the newly-formed bone is at first rough and thickened; but after some time, the layers become more consolidated and dense, and of a more uniform and smooth texture. It sometimes happens, however, that the bone retains its rough aspect during life, and continues to be dense, and of a high specific gravity. When the whole thickness of a bone is affected, the exudation in the production of new bone takes place both from the external surface, and also from the medullary canal of the healthy bone. After the removal of the sequestrum, the growths from the two ends unite before the bone has attained its original length, and a shortening of the limb is the result. Sometimes the union of the ends is imperfect, and a kind of false joint is formed. It very rarely happens that necrosis affects an entire bone; and this is very important, in consequence of the new being formed by the section of the old bone which has escaped the ravages of the disease. It is supposed, however, by Rokitansky, "that the periosteum and other surrounding soft parts, and even the newly-formed vascular tissues, are capable of producing an exudation which will become bone." This view seems to be borne out by the fact, that in a few cases recorded of spontaneous necrosis of the entire bones, new bones to supply their place have been reproduced. In experiments made by Heine on some of the lower animals, it was found that after the entire removal of a bone, a new one was reproduced spontaneously.

In persons of an unhealthy and scrofulous habit, the inflammatory process which succeeds necrosis may assume an unhealthy character, and instead of being accompanied with healthy granulations, may give rise to an ichorous discharge; and the process may degenerate into ulceration and caries of the bone. Another form of necrosis sometimes occurs, consisting of a gangrenous ulceration of the spongy bones. In these forms the bone becomes soft and brittle, and betrays a very disordered state of the constitution.

It must be obvious, that as there is a very considerable drain on the system in necrosis, occasioned by the profuse discharge for the purpose of throwing off the dead bone, and in the formation of the new, the system should be well supplied with nourishing diet; and with regard to the local treatment, the early extraction of the dead bone is desirable, and appropriate dressings should be applied to the ulcerated surfaces of the soft parts. These are subjects concerning which there is no ambiguity, nor is there anything which appears to call for either illustration or special attention; but from the nature of the processes which have been described, it must be obvious that the earlier the complete removal of the dead bone can be safely effected, the sooner the patient will be convalescent.

Having now given a somewhat detailed view of the nature of the processes which are observed in necrosis, I next propose to enter into the consideration of those hard osseous tumours which have received the name of *exostosis.*

The osseous tumours in exostosis may be formed either on the external or internal surface of a bone. These tumours often take place spontaneously, without any assignable cause, but they are supposed to be more frequently associated with a syphilitic taint in the system. It appears that they may be developed at any period of life, and may occur on any of the bones of the skeleton, and very frequently on the cranial bones. These osseous tumours present a variety of differences in structure, and may arise either from the compact or the spongy tissues of the bone; and it is found that their structure (as may be expected) partakes almost always of the nature or structure of the base from which they take their origin. Those tumours which are situated immediately under the periosteum, and are at first disconnected with the bone, will nevertheless, after having been formed for some time, become sooner or later firmly united with the contiguous bone. They vary in size, from that of a hemp-seed to that of a walnut, and in some cases these tumours acquire much larger dimensions. Exostoses are most commonly formed of compact structure, and, as might be expected from what has been said of their partaking of the nature of the part on which they are situated, they are found on the compact surface of the bones, and more particularly on the internal table of the bones of the head.

A tumour of this kind presents to the eye the appearance, and to the touch the form, of a nodule, with an abrupt margin; it is frequently separated at its base from the subjacent bone by a furrow of variable thickness; and sometimes there is a deep fissure between the nodule and the bone lying beneath. The density of these compact nodules is often very great, and in this state the disease is termed the ivory exostosis. These ivory tumours are of greater density and specific gravity than the normal bone with which they are associated, unless they happen to be connected with bone already in a state of induration. They are always composed of laminæ, and seem never to be intermixed with spongy tissue. The density of the tumour is owing to the greater number of laminæ contained in a given space, when compared with the number of laminæ found in the same space in normal bone. The Haversian canals are small, and few in number, but a well-defined lamellar system is found surrounding them. The bone corpuscles are irregularly scattered in the substance of the tumour, and in some places they are clustered together, while in other parts larger tracts are found entirely destitute of them. The colour of these exostoses is a yellowish-white, and they are of a lighter hue than the bone to which they are attached.

Rokitansky appears opposed to the hypothesis that the origin of these tumours has any relation to syphilis, and he believes the cause of their appearance to be entirely unknown. When the exostoses are of a spongy texture, they are connected with a rarefaction or expansion of the spongy bones, termed by the German pathologists *osteo-porosis.* They present many varieties in their structure, and may arise either from the spongy or from the laminated structure, or from both together: they are then compounded of an internal spongy, and an external laminated layer of the compact tissue. These mixed osseous tumours are not unfrequently found near the joints, at the head of the tibia, or on the shin, and on any of the other long bones of the skeleton. In the skull, the disease is accompanied with an expansion of the diploe, in which case there may be an exostosis on both the external and internal tables corresponding in situation with each other. In the spongy forms of exostosis, the structure may remain permanent after its development; but more commonly new matter is formed in the interior, and the structure of the bone is more or less condensed; but this altered structure is often succeeded by the bone being again rarefied, and thus the growth of the spongy exostosis outwards may be affected, and may increase to a considerable size. When this disease affects the spongy bones of the face, it has been known to produce the most hideous appearance. Some examples of these cases are to be seen in the Hunterian Museum. When the exostoses have acquired a certain magnitude, they usually continue through life unchanged. The ivory texture of the excrescence, in this disease, sometimes diminishes in size by condensation, or it may become necrosed, and be thrown off.

The spongy exostoses sometimes degenerate into caries, and in this way disappear. These appear to be the processes by which the system may be spontaneously released from the osseous growths of exostosis. Independently of exostosis, the bones during inflammation exude a fluid which ossifies, and forms a layer on their compact surface, this substance has received the name of *osteophyte*. At the commencement of this process the exudation is soft and gelatinous; it afterwards becomes tough and elastic, resembling cartilage, and in the end it ossifies. It appears that this exudation is associated with nearly all inflammatory conditions, whether of abscess or necrosis of the bones. There are many variations of form assumed by these osteophytes, as well as differences in structure.

They sometimes appear to be composed of "delicate fibrils and lamellæ, which are fixed at acute angles on the surface of the bone, and give it the appearance of velvet, or felt with a very fine nap." Though these osteophytes are at first in contact with the bone, yet they may be easily raised from it in large pieces, and although for some time separated by a layer of cellular substance, they become fixed to the bone when this membrane disappears.

The exudations which terminate in osteophytes sometimes form plates, and often anchylose some of the vertebræ by the ossification of the anterior common ligament. They occur also on the inner table of the skull, and, indeed, wherever inflammatory processes are going on in the bones.

Osteophytes have been known in a few cases to cover large portions, or nearly the whole of the skeleton; they are sometimes associated with atrophy, and at others with hypertrophy, of the bones. Although we generally find the exudations accompanied with an inflammatory condition of the bones and periosteum, the precise condition of the system that gives rise to the inflammation and exudation is not yet determined. In the imperfect union of fracture, these plates then constitute the union of the ends of the bone. To give a minute detail of the structure of all the forms of osteophytes would occupy too much of your attention in this short course, I have therefore merely touched on the subject to show the distinction in their character which has led to their separation from exostosis.

The bones of the skeleton are likewise liable to anomalies in number, size, and form. The absence or addition to the number is not very common, but is coincident with conditions of the system in a state of perfect health, and not referable to any pathological conditions: it is not, therefore, my purpose to give any detail of cases of variations of number. With regard to variations in size depending on pathological states of the bones, the case is quite different, and deserves a few remarks. In hypertrophy of the bones, they may increase in size by the addition of new osseous matter deposited on their surface beneath the periosteum, without any change taking place in their density or specific gravity; the size of the medullary canal remains the same, but the compact substance acquires a considerable augmentation of thickness. When the increase of substance takes place in the interior of the bone proceeding from the Haversian canals, and involving the whole of the medullary system, the bone becomes more dense, both in the compact and cancellous tissues. In the latter, the walls of the cells increase in thickness, and the medullary cavity diminishes in size; the diploe disappears, and the whole bone becomes indurated. When the hypertrophy takes place both internally and externally, the bulk and density of the bone are both increased. The increase of the bones, both internally and externally, is preceded by the deposition of a superabundance of cartilaginous matter, in which the salts of lime are deposited, as in normal bone.

When the disease attacks the bones of the skull, or when it affects considerable portions of the skeleton, it becomes a serious disorder. It is a remarkable circumstance, that when the bones of the skull become hypertrophied, those of the face often diminish, so that there are actions opposite in their effects—namely, hypertrophy and atrophy, going on in the system at the same time.

The conditions of the system that give rise to these changes in the bone are not yet determined, nor do the bones themselves give any premonitory signs of the advent of the disease. The surface of the bone continues smooth, and the periosteum natural, even when the bone has acquired the compactness of ivory. In other cases, the increase in the volume of the bone is preceded by an inflammatory condition. The seat of the inflammation may be either the periosteum and the compact tissue, or the medullary membrane. When the external surface is affected, an exudation takes place on the surface of the bone, which becomes ossified into laminæ; this forms a layer, which is sometimes separated from the surface of the bone by a layer of spongy tissue. When the inflammatory process has its seat in the medullary membrane, it leads to increased density either of the compact or of the spongy tissue, or of both these structures. It may be easily imagined that these organic changes cannot take place without affecting the texture of the diseased bone; and it is found accordingly, that the substance of the bone becomes hypertrophied in consequence of the expansion and infiltration of the tissue connecting the capillaries of the medullary canals and cells. The result of these organic changes is a thickening at the affected portions, the other sections of the bone remaining free, so that the surface often presents a rough and uneven appearance. The inflammatory states of the bones under consideration are frequently experienced by persons labouring under a rheumatic, syphilitic, or gouty constitution, and the treatment must depend on the nature of the causes that are associated in the production of the disease; the local treatment is that common to other organs affected with chronic inflammation.

The opposite state to that of hypertrophy, is atrophy of the bones. Whatever causes lead to the insufficient nutrition of bone, tend at the same time to diminish its volume. There are, consequently, many states of the system which may lead to atrophy, such as indifferent diet, want of action, exhausting diseases, palsies, fractures, anchylosis, and, indeed, anything which tends to impede the flow of blood to the bones, are all accompanied with atrophy. From the nature of the various causes just mentioned, any of the bones of the skeleton may be affected. In many cases, the bones diminish both in length and thickness, and the medullary canal becomes contracted: this condition of the bone is termed *con-centric atrophy.*

Independently of special causes, the bones of aged persons often become atrophied; they are then brittle, and break with a comparatively slight force. It appears that atrophy always begins in the medullary canals and in the diploetic structure, the cells of which enlarge, and the walls and lamellæ of the cancellous structure become attenuated, and finally disappear. The compact tissue becomes changed, and resembles the spongy diploetic structure; and the outer layer only remains unaffected, but almost as thin as paper. As the atrophy of the spongy substance advances, the external layer only remains, and incloses a cavity with mere traces of spongy tissue at its periphery, or a soft substance with large cells. When the spongy substance is entirely removed, the thin external walls of the bones approach each other, and form a single plate. When the cavity within the bone is enlarged, it is called by Mr. Curling *ex-centric atrophy.*

The con-centric form of atrophy occurs in the larger medullary canals, the ex-centric in the bones of the pelvis, ribs, and vertebræ. It will be easily imagined, that when such great organic changes take place in the bones, their physical characters alter in proportion; and accordingly, the bones thus affected become flexible, and crack when they are bent. As the loss of the internal portion of the bone proceeds, the external portion becomes diminished, and hence the skeleton in *senile* atrophy, together with the whole weight of the body, is less than in the normal state. The volume of the bones may be also diminished by continual pressure, such as that produced by tumours and aneurisms; but to these purely mechanical causes I do not wish to engage your attention.

The following proportions were found to exist between the inorganic and organic matter, in a healthy, a thickened portion, and in an exostosis formed on the same bone, analyzed by Lassaigne :—

	Healthy.	Hypertrophy.	Exostosis.
Inorganic	57·	58·4	54·
Organic...	43·	41·6	46·

Having now given a description of the nature and growth of osseous tumours, I shall occupy the few spare minutes of your time with some very brief remarks on the nature and diagnosis of the soft tumours affecting the bones. Perhaps there is no subject in which the microscope has been of greater utility to the practical surgeon, than in determining the structure of the soft tumours of the osseous system. Up to a very recent period, tumours of the bones of the most heterogeneous and diversified character have been assembled together, and no distinction has been made between those of the mildest and those of the most malignant tendency. Thus, the older writers grouped together, under the term "*osteo-sarcoma*," the cartilaginous and osseous, the osteoid, the myeloid, and the enchondromatous tumours, and confounded these non-malignant with the scirrhous, medullary, and aveolar tumours. Under these circumstances, we cannot wonder that much discussion should arise amongst surgeons on the propriety of, and the varied success resulting from, the removal of these mixed forms of tumours.

When we look into authors on osteo-sarcoma, we find that they had no very precise idea of the real nature of the tumours comprised under this term. Some wished to restrict the term to those which are decidedly scirrhous, whilst others describe them to be of a cartilaginous texture, and none seem to have satisfactorily determined whether they are or are not wholly malignant. With such a state of confusion and complication, we need not be surprised that some operations have been attended with complete success, while in other cases the diseases have returned and destroyed the patient. To give an idea of the complete difference in the views entertained by surgeons on this subject, it is only necessary to refer to one or two of those who have confounded together the malignant tumours with those of the non-malignant character.

Thus, according to Callisen, osteo-sarcoma is a disease by which the texture of the bones is converted into a lardaceous substance, having a tendency to carcinoma. Boyer considers it a disease analogous to cancer. Dr. Cuming, of Glasgow, considers that though all varieties of osteo-sarcomatous tumours are highly formidable, yet he says "they are not all really cancerous." Mr. Mayo observed of these tumours, that they have not "much malignity;" so that if all the portion of the bone involved, with part of the adjacent sound bone, be removed by amputation, the complaint seldom reappears, either in the part, or in another bone. It would be an almost endless task to enumerate the different opinions, with the various results of these tumours; but we see how little dependence can be placed on the results respecting the cases that have been detailed, unless we could be secure of the real nature of the tumour removed. But the diagnosis of the character of the tumour is in some cases by no means easily made, and I have occasionally been in consultation with the most distinguished surgeons of the metropolis without arriving at anything like a satisfactory result.

The diagnosis of the nature of many tumours connected with the bones is one of the problems in surgery most difficult to solve; the data apparently in many cases are not sufficient for the purpose. The hereditary tendency to diseases of an organic type, the aspect of the patient, the situation of the tumour, its character to the touch, and the history of its formation, are all circumstances to aid in the research; but all these are often insufficient to enable the surgeon to arrive at more than an hypothetical conclusion. An example will suffice to show the truth of these remarks.

A few years ago, I was solicited by a gentleman to remove a tumour situated at the back of the thigh. On examination, I found it was deep-seated, soft to the touch, and apparently movable on the bone; it was of a considerable size, and had only been recently detected by the patient. Having some suspicion of its character, I advised his having another opinion before its removal, and Mr. Guthrie was consulted; but that gentleman being of the same opinion as myself—namely, that it presented a formidable aspect, it was agreed to take the opinion of the late Sir Astley Cooper. In this consultation, Sir Astley stated, that although he was of opinion it was very likely to turn out malignant, yet that its removal would give the patient a greater chance of a prolonged life. However, considerable alarm having been excited in the minds of the patient and his family by these consultations, he was advised to take the opinion of Mr. Lawrence, and subsequently that of the late Mr. Earle. The result of their several opinions was, that it was a tumour of an uncertain character, but all agreed on the propriety of its removal.

At length the family decided that Mr. Earle should be selected to perform the operation. On cutting down on the tumour, it was found to be a medullary cancer connected with the bone, with ramifications so extensive that its complete removal could not be accomplished. The consequence was that the wound did not heal, and the patient sunk from exhaustion at the end of about three months. In this case it will be observed some of the best surgeons in London were consulted, notwithstanding which nothing but an uncertain knowledge could be formed of the character and connexions of the tumour, and it was, as the result proved, a case which required either amputation at the hip-joint, or to be left unmolested.

In order to assist us in forming a correct diagnosis of the nature of tumours, it has been suggested, and attempts have been made, to ascertain their character by means of a grooved or hooked probe, but with what success this plan has been attended I am not prepared to state; still it seems to hold out a feasible prospect of enabling us to form a better opinion of such cases before operating for their removal. It is the opinion of many surgeons that malignant diseases in the bones are not so liable to return after operation, as those of the soft parts; but as these opinions were given when the real nature of tumours was less understood, it will require further investigation to determine this question. Myeloid and enchondromatous tumours were, until very lately, considered malignant; and this may have given rise to many of the opinions formed of the curability of the patient suffering under malignant tumours of the bones by means of their removal.

LECTURE III.

FRACTURES OF THE BONES.

On fractures and reparation of bone. Unequal effects of falls in the production of fracture. On the formation of primary and secondary callus. On fractures of difficult reunion. Theory of Sir Astley Cooper; his views shown to be erroneous. On the fractures of the neck of the femur, of the patella, and of the olecranon and coronoid processes. Some remarks on fractures attended with difficult diagnosis. Conclusion.

In the lecture of this evening, I propose to enter briefly into the subject of fractures, and the reparation of fractured bones, and also to advert to some special fractures which are likely, in practice, to give rise to mistaken diagnosis. Having already spoken, though briefly, on the liability of bones to fracture in particular diseases, it now remains only to consider the subject of those fractures which are owing to mechanical violence. The bones are liable to a great variety of mechanical injuries which terminate in fracture; indeed, the causes of fracture are so numerous that it would be difficult to select any one that may be said to predominate over others, either in the number of its victims or the intensity of its effects: this, however, is a subject merely for statistical research. In this immense metropolis, where so many buildings, both public and private, are in course of erection at the same time, and where the scaffoldings so frequently give way and precipitate a number of unfortunate artisans from great heights to the ground, we meet but too frequently with very severe cases of contusions and fractures. It is curious to observe on these occasions the great difference in the effects produced when a number of workmen are precipitated together: some are killed on the spot; some may have either one or many bones fractured; while others escape without injury. It may be easily imagined that the differences are attributable to accidental circumstances which it is not necessary to investigate on the present occasion; but it really does sometimes appear almost miraculous that some individuals escape fracture of the bones, in falling from great heights, while others, in merely slipping from the curb-stone of the pavement, fall and fracture some of the bones of the extremities, or of the skull. From what has been said in a former lecture relative to the great strength of bones, and of the great force which is requisite to crush them, we are sometimes surprised to find that the bones are so easily fractured, even in the strongest and most healthy persons; but it must be remembered that there are great differences in the nature and qualities of the ground, and this difference seems generally to produce corresponding effects on the softer tissues, as well as on the bones; and moreover, we must bear in mind that the percussion on reaching the ground is much greater than that due simply to the velocity which the body has acquired in falling, it being proportional to the weight of the body, multiplied by the square of the velocity. Such being the case, we must no longer be surprised that fractures of the bones sometimes result merely from tripping on the feet in walking, and falling to the ground, more especially when the surface on which the body falls is composed of compact and rigid materials. When a bone, such as the shaft of one of the cylindrical bones of the extremities, has been fractured, and the ends of the fractured parts become disconnected, the first step to be taken for the repair of the mischief is to bring the disconnected parts into juxtaposition, and then to apply such mechanism as will retain the bone, during a greater or less period, in the desired position. To accomplish these ends, it must be manifest that the means to be employed will vary with every variety of fracture; and therefore, before entering into any details of the treatment of special cases, it will be desirable to explain the present state of our knowledge of the nature of the process by which a broken bone becomes re-united.

There appear to be two processes by means of which a fractured bone may be repaired: the first is that which is denominated "by the first intention;" and the second, that which is designated by "suppuration, or the second intention." In the reparation of fractured bone by the first intention, it is observed, that when the extravasation of blood produced by the fracture is absorbed, and the contemporaneous injuries of the soft parts have partially subsided, an inflammatory process is set up; at the same time the medullary membrane becomes red and tumid, and secretes "a loose red mass," (the *substantia media* of Breschet,) which adheres to the broken surfaces of the bone, and soon after unites with the surrounding parts. By means of this substance, each of the fractured ends is enclosed in a sort of capsule, consisting of the swollen soft parts. The internal layer of this capsule is composed of the periosteum, which is usually torn from the surface of the bone to some variable distance from the seat of the fracture, and at length becomes so intimately united with the surrounding soft parts as to be no longer distinguishable from them. A viscous, reddish-looking fluid, which is exuded on the inner surface of the periosteum, fills up the space between the broken fragments of the bone and the membrane. While these processes are going on, a reddish, semi-fluid, gelatinous substance exudes along the line where the periosteum remains connected with the bone; the quantity of matter exuded is greatest in the neighbourhood of the fractured parts. As this substance increases in quantity, it advances from the point where the bone and periosteum are in contact towards the seat of the fracture, keeping close to the inner surface of the capsule which lines the soft parts, and leaving a space between the exudation and the bare extremities of the bone, the bone itself being filled with the same kind of viscid fluid. As this exudation ossifies it assumes a more definite organized structure.

If the fractured ends of the bone are in a favourable position, the masses of callus which are first formed assume a cylindrical shape, and proceed to the capsule, which has now acquired a fibro-cellular texture. As the fibrous capsules become absorbed, the two portions of callus from the opposite ends of the bone unite, and enclose the fractured spot. The process just described, which takes place on the outer side of the bone, is of the same nature as that which takes place in the medullary cavity. The substance effused easily ossifies, and obliterates the medullary cavity. These are the changes which are described as taking place in the production of provisional callus. However, a considerable time before the perfect formation of the provisional callus has been effected, the process for the formation of the definitive callus has already commenced. The fluid which lies between the ends of the bone and the soft parts gradually assumes a fibro-cellular structure, in which a vascular communication with the surrounding parts is set up. The primary and secondary callus which are formed at length unite together; but they are distinguishable from each other by their difference in structure, the latest-formed callus being the softer of the two. After a period of greater or less duration, depending on constitutional conditions and other extraneous circumstances, the broken extremities of the bone become surrounded by an osseous sheath, which adheres to the bone, and forms the link of union between the fractured ends. After the lapse of about four or five months from the time of the accident, the broken surfaces of the bone unite within the osseous sheath, the interposed tissues disappear, and the repair of the fracture is complete.

While the consolidation of the new bone is progressing, the swelling and inflammatory condition of the soft parts surrounding the broken bone gradually subside, and the medullary cavity begins to be formed at the fractured parts. The Haversian canals in the new bone gradually increase in size to such an extent that its structure resembles a kind of an areolar, instead of a solid texture. By a further process of absorption the areolæ are removed, and a new medullary cavity occupies their place. This latter process, however, does not always take place, but a layer of solid bone permanently intersects the medullary canal. The callus is invested with a fibro-cellular membrane, consisting partly of the old periosteum, and partly of new membrane, which is formed out of the exudation from the soft parts, and becomes a new periosteum, resembling the healthy structure of that membrane. After a time, the callus attains the structure of healthy bone; it becomes dense, and diminishes in size, so that if the ends of the bone have been kept nearly in apposition, and in a quiescent state, the united bone presents but little trace of the fracture.

From this description it will be perceived that the firmness of the union increases from the date of the fracture, extending through a period of several consecutive weeks. The process which takes place in the bone at this time is deemed by pathologists to be analogous to that which takes place during the union of soft parts by first intention. The process just described implies that all the conditions are favourable; but these may be affected by various circumstances dependent on the peculiarities incident to special fractures, or to some mismanagement in the treatment. The idea which was formerly entertained, that the periosteum is ossified in the formation of callus, is now no longer tenable. It not unfrequently happens however, that the process for the complete repair of bone is, from some cause or other, arrested at an early stage of the transformation of the materials thrown out. This may arise from a deficiency in the materials of the callus, and then the process proceeds no further than the formation of the fibro-cellular or ligamentous union. The cellular membrane is sometimes interposed between the broken surfaces of the bone, and allows of a small gliding motion, being, in fact, a kind of synchondrosal joint. In other cases, there is a greater degree of motion allowed by the formation of a diarthrosal joint. In this case a ligamentous articular capsule is formed, and the joint is lined by a smooth membrane, which secretes synovia. When the ends of the bone overlap each other, the surfaces of the bone in contact adapt themselves to each other, and become covered with a layer of tissue, which is either fibro-ligamentous or fibro-cartilaginous; or they may articulate with each other by means of an intervening ligament, which corresponds in function to an inter-articular cartilage, and which allows of considerable motion.

The articular capsule is the product of inflammation of the soft parts, but the fibro-cartilaginous layer which covers the ends of the bone is considered by Rokitansky to be secondary callus, arrested in its metamorphosis, and converted into a fibroid tissue.*

In the more severe and extensive injuries of bone, as in compound fracture, the period of the process of reparation is of longer duration, and the process itself, instead of being that which has been described as union by first intention, is the process designated "union by suppuration," or secondary intention. In this process, as in the former, a capsule of the soft parts is formed around the ends of the bone, but it contains, on account of the inflammatory condition of the surrounding parts, a great quantity of pus. The capsules formed at the ends of the bones are lined with "a greyish-red, translucid, jelly-like, granulating layer, which is covered with the pus," thus constituting a closed abscess. The primary callus, as in the process of union by the first intention, exhibits the appearance of a gelatinous exudation, which becomes cartilaginous, and afterwards forms a bony tissue. It takes its origin from that part of the bone which has not been divested of the periosteum; and from thence it advances on the inner surface of the capsule towards the broken ends of the bone. In some of these severe forms of fracture, the ends of the bone (which are denuded of periosteum) are bathed in pus, and the open

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* Rokitansky, Manual of Path. Anat., vol. iii., p. 150.

end of the medullary cavity, which does not contain the plastic exudation, appears of a dull-white colour, extending to some depth; the cells and spongy tissue participate in the altered condition, and the medulla is shrunk, soft, and discoloured. If we examine the state of the parts beyond the limits of these organic changes, we find that the medulla is swollen and inflamed. The ends of the bone being bathed in pus, become necrosed on the inner surface, and this condition extends through its entire thickness, its extent being determined by that portion which is divested of periosteum and medullary membrane. When the necrosed portion of the bone has exfoliated, healthy granulations appear, and the surface of the fragment becomes the base for the deposition of callus, or new bony matter is deposited. As the exfoliation of the dead bone takes place very slowly, the formation of callus is proportionably delayed; but while this is going on, there is often great exhaustion of the system. It sometimes happens that the granulations which were formed for the deposition of bone are changed into a fibro-cellular or ligamentous state, and hence the repair of the fracture is incomplete, and a permanent loss of bone is the result, attended with shortening of the bone, ugly cicatrices, or an artificial joint. In amputations, the ends of the bone are covered with a fibro-cellular membrane, except when an inflammatory process of an acute type is set up, which then leads to suppuration. Under these circumstances, the stump becomes necrosed, and exfoliates, and the cure is effected by granulation. The apertures made in the bones of the skull by the trephine are very rarely entirely filled up by osseous matter, but by the substitution of fibrous discs, which adhere to the dura mater on one side, and to the periosteum on the other. Such, according to the most recent researches of both English and French pathologists, is the brief outline of the theory of the reproduction of osseous matter in the repair of fractured bones.

I now propose to call your attention to some of those forms of fracture of bones which are attended with very difficult or otherwise uncertain re-union, and afterwards, if time permits, I shall refer to fractures which are attended with difficult diagnosis.

Amongst the bones which are repaired with great difficulty, or which are often very imperfectly repaired, after fractures, may be selected the neck of the femur within the capsular ligament, the condyles of the humerus, the olecranon and coronoid processes of the ulna, to which may be added the patella. Perhaps there is no bone in the human body, the fracture of which has given rise to so much discussion as that of the os femoris. It has long been a subject of dispute whether the fracture of the neck of the femur within the capsular ligament is, or is not, capable of being united by osseous matter. It appears from the observations of Sir Astley Cooper, that fracture within the capsular ligament is of very rare occurrence before the age of fifty years. He states, that out of about 225 cases during thirty years' practice, he has only known of two occurring before that period of life; and he laid down a general rule, that this fracture rarely occurs before fifty years of age, and that dislocation seldom occurs after that period; but of course there are some exceptions to this rule. It seems from the statistics of this accident, that women are more liable to this form of fracture than men, which Sir Astley Cooper ascribes to the greater inclination of the neck of the bone, and to the more delicate constitution of females. The organic changes which take place in the bones, as age increases beyond that of fifty years, are such as seem to affect sensibly the strength, elasticity, and even the form of the neck of the femur. Sir Astley Cooper remarks that the bones of old persons may be cut with a knife, whereas no impression can be made on them at the adult period.

It would appear that the organic changes which tend to diminish the earthy components of the bones, are unfavourable to the setting up of a process for the supply of their materials; in fact, that the process of decay and reproduction of bone cannot go on at the same time in the same osseous tissue; indeed, we find this law holds good in necrosis, when the new bone is secreted, independently of the dying and dead bone.

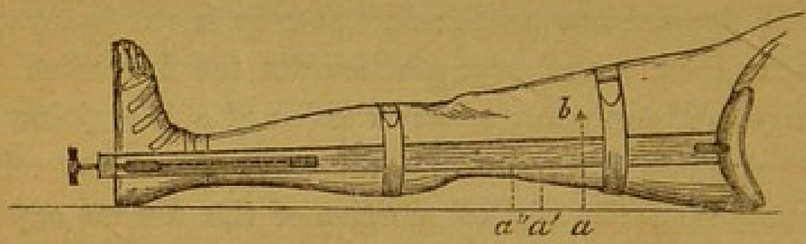
The fracture of the neck of the thigh-bone may be distinguished from dislocation by the crepitus felt on motion, the position and length of the limb, and the degree and kind of motion in the limb. Moreover, in fracture there is a diminution of the length of the leg, the knee-joint and foot are everted, and the trochanter can be rotated backwards; but in dislocation of the hip-joint upwards there is also shortening of the leg, but there is the absence of the crepitation; the trochanter cannot be rotated backwards, and the knee and foot are everted. The evertion of the knee and foot is not produced instantly on the fracture, but it occurs soon afterwards in consequence of the force of the muscles which roll the head of the femur outwards being greater than that of those which roll it inwards. In fracture of the neck of the femur, very little pain is produced during the extension of the limb, but during the rotation there is considerable pain, which is most probably caused by the frictions of the broken end of the bone against the capsular ligament.

It is well known that Sir Astley Cooper always taught the doctrine, that fractures of the neck of the thigh-bone were incapable of being repaired by osseous matter, and that in the whole course of his practice he had never met with a single instance, nor could he meet with any one who had seen a case where such an occurrence had happened; and that union within the capsular ligament (when any such union takes place) is always by membrane. However, it appears that he had no sooner published the last edition of his work, "On Fractures and Dislocations," than Mr. Swan forwarded to him a specimen of the thigh-bone, in which the fracture of the neck had become re-united by osseous matter. Sir Astley retained the specimen until his death, and it appears that he never had the courage or policy to promulgate the discovery of the error of that doctrine which had so pervaded his mind, and which had misled the profession during a period of forty years. The specimen of Mr. Swan is now in the museum of the Royal College of Surgeons. Besides which there are the cases of Mr. Hodgson, published in the seventh volume of "Guy's Hospital Reports," the preparations of which are also in the museum of the Royal College of Surgeons. These specimens render the question of the possibility of the re-union of the neck of the femur within the capsular ligament completely verified.

When we reflect on the bearing of these facts, we cannot overrate their importance, inasmuch as we may improve on the former methods of treatment, and persevere to effect an osseous union, whenever the nature of the case will permit; whereas, by acting on the hypothesis of Sir Astley Cooper, we may be disposed to neglect the means of its accomplishment, in despair of a satisfactory result. However, it must be manifest, that since we can find only a few examples of osseous union of the neck of the thigh-bone, to set against the long series of cases which have been recorded, and the numerous morbid specimens in our museums, in which there is either a mere membranous union, or no union whatever, our prognosis of the result of the treatment (in the present state of our knowledge) must always have a doubtful character with reference to the perfect recovery of the patient. And this should be expressed, since otherwise the patient and friends may be disposed to question the propriety of the plan of treatment, and assign the failure of osseous repair to the mismanagement or neglect of the surgeon, instead of ascribing the failure to its true cause. In these cases, the reasons assigned for the failure in the reparation of bone are, the great difficulty of keeping the broken ends of the bone constantly in apposition and in a quiescent state, for there is a constant tendency in the muscles to draw the limb upwards, thus displacing the broken surfaces, so as to prevent their union. Every movement of the pelvis, such as in the evacuation of the fæces, and every change of position, tends to disturb the broken ends of the bone. Again: the fracture is generally accompanied with laceration of the periosteum, and then the nutrition of the part of the bone lying between the divided portion of that membrane and its blood-vessels is impeded. In addition to these circumstances, we must bear in mind the advanced age of the persons to whom this accident most frequently occurs, as well as the atrophied state of the skeleton. The repair is also supposed to be influenced by the effusion of synovia into the joint. The usually received opinion of the causes of defective ossification are, however, deemed unsatisfactory by Rokitansky, who observes that they do not explain why the formation of the callus is so backward, and the object so often frustrated. He is of opinion that the causes are, first, that no primary or provisional callus whatever is formed; and secondly, that the secondary callus is arrested in its development at the stage of the formation of fibroid or ligamentous tissue; and that it is the want of the first callus that for the most part arrests the formation of the secondary, and leads to the construction of a false joint. He, like Sir Astley Cooper, ascribes the want of primary callus to the small vascularity of that portion of the fibrous capsule of the joint which occupies the place of the periosteum; also to the great density of the structure of the capsule, and its close adhesion to the bone, as well as to the distance of the soft parts, and the dilution of the exudation, which never becomes organized into bone.

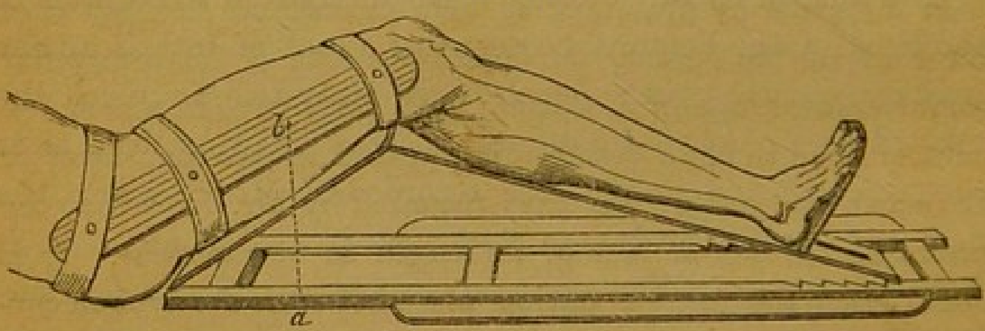
In a memoir by Mr. Canton, "On Interstitial Absorption of the Neck of the Femur," he describes a case of intra-scapular fracture, occurring in a female, aged sixty-two, in which the neck of the bone had totally disappeared in two months after the accident; and in the case recorded by Mr. Howship, the neck had lost half an inch of its length in two months. It is found that the friction taking place between the broken surfaces sometimes wears down the intervening fibrous membrane, and renders them quite smooth; and these two smooth surfaces of bone become polished like ivory, and are left to articulate with each other. Sometimes these surfaces are flat, and at others the one is concave and the other convex, forming a kind of ball-and-socket joint. The ivory-like polished surface is found by Professor Quekett to be owing to the consolidation of the bone produced by the deposition of bone in the Haversian canals. In the treatment of fracture of the neck of the femur, the object to be kept in view is the same as in that of all other fractures—namely, to retain the broken surfaces of the bone in contact, and in a quiescent state for a period of sufficient duration for the repair of the fracture. To accomplish this object there are two methods extensively adopted, the principles of which are diametrically opposed to each other; one of which consists in extending the limb by a mechanical force, and by bandaging the pelvis and limb to a long straight splint, as in figure 10.

Fig. 10.



The other plan is to keep the limb constantly flexed on double or triple inclined splints or planes, the muscles affecting the limb being retained in a state of rest and relaxation, (as seen in fig. 11.)

Fig. 11.



The use of the straight splint is advocated by Dessault, and, I believe, is used at most of the London hospitals. The principle of the latter plan, which was first recommended by Pott, and used by Sir Astley Cooper, Dupuytren, Mr. Hodgson, &c., is now adopted by many of the best surgeons in this country. The objection made to the long straight splint of Dessault is, that the skin of the pelvis and leg are so pressed on by the apparatus as to occasion great and almost insupportable suffering, which may be succeeded by inflammation, suppuration, and gangrene; so that when the splints are removed at the end of three weeks, sloughs are sometimes found on the leg and foot, so as to require amputation, under which the patient may sink. Another disadvantage of the straight splint is, that the ends of the fractured bone, not having a vertical support, may overlap each other, and the limb may become shortened. Thus, for example, in fig. 10, let us suppose the femur to be fractured at the point *b*. By means of the straight splint the bone, if not steadily supported by other means below the fractured part —that is, in the direction of a, a', a''—the bone will fall below *b*, and the broken ends, not being kept in a state of approximation, will be liable to be drawn on each other. This shortening frequently occurs in fractures of the shaft of the femur, and these cases may be met with in patients after treatment in our hospitals. According to Dupuytren, this was the case with the late General Lafayette, and he adds, "I have tried every means to obviate the results by padding the splint, but without success." There is great difficulty in retaining the limb in position merely by mechanical extension; for in the attempt to reduce the fracture by this means, the power of the muscles is so great as to require the force of several assistants, and as soon as they relax their efforts the limb is drawn back again. But the case is very different when the flexed position is adopted, both in reducing the fracture, and in retaining the limb in position. The course to be pursued is to place the patient on the back; the pelvis is then flexed, or held by assistants, the thigh is raised gently, and drawn forwards, and the leg flexed at the knee-joint. In this way the limb is easily drawn to its normal length without violence, and the foot regains its natural direction by the relaxation of the adductors, which cause the eversion of the foot, and of the glutæi, which draw the shaft of the bone upwards.

The limb thus treated will retain the parts in position without any tight bandaging, and without causing the same amount of irritation that the other system produces. When a triple inclined plane is at hand, it is a very excellent instrument for promoting the ease and comfort of the patient, and for the adjustment of the relative angles of flexion of the body. The head piece is elevated at an angle of 45°, and the leg and thigh planes may be kept at a similar angle. A great many machines have been invented, such as those of Hippocrates, Heister, Paré, Dessault, Amesbury, Liston, Luke, Salter, and others, for the treatment of these fractures; but whatever may be the character of the mechanism employed, the principle laid down by Pott is that which I have adopted, as being the most rational, and attended with the best results; it prevents the shortening and overlapping of the ends of the bone, and the formation of a false joint. The preference given to the straight splint is owing to its simplicity; but this is not a sufficient recommendation to compensate for defects.

With respect to the time necessary for the firm re-union of the neck of the femur, it is considered that it is double the time that would be sufficient for the cylindrical portions of the same bone; but, of course, there are many circumstances tending to vary the period of treatment—such as the nature of the fracture, the constitution, and the age of the patient. It will be seen that when the age only is taken into consideration, the time increases almost directly with the age.

In six cases, taken promiscuously by Dupuytren, the ages and times of treatment were the following :—

Age of patient.	No. of days under treatment.
48	54
58	62
61	87
67	85
68	84
72	90

In two of the cases treated by Mr. Hodgson—

Age.	Days.
67	98
90	103

When the fracture of the neck of the femur takes place without the capsular ligament, or when it is driven into the cancellous structure of the shaft, the repair will take place by osseous union, and the limb, though slightly shortened, will be firm and useful, and enable the patient to walk easily, though with a slight limping gait. It is curious to observe, in some of these cases of fracture of the neck of the thigh-bone, the means employed by Nature to supply the loss of power to support the body. In a case furnished to Sir Astley Cooper by the late Mr. Powell, in which the neck of the femur was driven into the cancellous structure, the trochanters were enlarged by the deposition of osseous matter, and thus they formed a kind of crutch upon which the external portion of the ilium and the lower margin of the acetabulum rested. When the fracture of the thigh-bone happens to take place below the trochanters, the theory of re-union does not require any special remarks, or present any difficulties either in diagnosis or in treatment; but the re-union in these cases under ordinary circumstances takes place by osseous matter. In young children, up to three or four years of age, there is often considerable difficulty experienced, in fractures of the femur, to keep the limb and trunk from turning upon each other, and displacing the ends of the broken bone. To prevent this, and to allow the trunk a limited degree of motion, a double inclined splint to confine the limb, and, connected with it, another splint, articulated with its plane at right angles, seems to answer the purpose very well, and this arrangement prevents the restlessness incidental to a complete restriction of the body in such very young patients.

The next bone which is found very difficult to repair by osseous union, is the coronoid process of the ulna. The fracture of this process is usually produced by falling forwards with the arm extended, and pitching on the ground on the hand. The force is transmitted from the hand through the fore-arm to the elbow-joint, and the coronoid process, the only portion of bone to transmit the impulse to the humerus, being incapable of sustaining the pressure, is torn away from the shaft of the ulna, and the olecranon process is driven backwards. In these cases, when the arm is extended, the ulna is then projecting backwards; but when the arm is drawn forwards and bent, the deformity disappears. In the treatment, the arm must be extended, and it should be retained in this position during a sufficient period for either the osseous or fibrous union of the process; but the former does not readily take place, and the fibrous union allows of a sliding motion in the elbow-joint during the extension and flexion of the arm. Sir Astley Cooper is of opinion that no treatment that we can adopt will be successful in producing osseous union of this process; and he observes that the coronoid process, like the head of the thigh-bone, loses its ossific nourishment, and has no other than ligamentous support, which does not appear capable of producing the least attempt at ossific union.

In fractures of the olecranon process, the symptoms are so obvious that it is not difficult to detect the nature of the injury. The patient complains of pain at the back of the elbow-joint: in passing the finger along the back of the ulna, a hollow can be felt between it and the olecranon process, which is drawn up by the extensors of the arm from half an inch to two inches; and this portion can be easily moved from side to side out of the line of the axis of the shaft of the ulna, but is not capable of being drawn downwards without very great difficulty. When the arm is bent, the distance between the ulna and olecranon process is much increased, as may be easily imagined from the structure of the elbow-joint and the nature of the case. The patient has little, if any power to extend the limb; any attempt to do so is accompanied with considerable pain, but the flexion is performed with great ease. There is not any crepitus to be felt between the ends of the fractured segments of the bone, unless their distance from each other is so slight that they may be readily brought into contact, which is then easily effected. The fracture of the olecranon is usually accompanied with swelling and tumefaction of the surrounding soft parts, with an appearance of ecchymosis, and a considérable effusion into the joint. The degree of the inflammatory symptoms depends on the amount of the violence which produced the injury.

In the treatment of this fracture, the swelling is first reduced by the application of evaporating lotions; or, if the inflammation is acute, the application of leeches may be necessary. When the inflammation has subsided, the arm is first to be brought into the straight position; the upper part of the olecranon is then to be pressed down in contact with the ulna; a moistened bandage is applied above and below the elbow-joint, and two pieces of linen laid, one on each side, the ends of which are passed underneath the bandages, and are brought back again over them, and tied tightly, so as to draw the rollers above and below the joint together, and retain the surfaces of the bone in a state of approximation. A splint is then placed and bandaged on the fore-part of the arm, to retain the limb in the straight position, the parts being kept cool by evaporating lotions. The position of the limb is thus the reverse of that employed in fractures of the coronoid process of the ulna and the condyles of the humerus. It will be necessary to pursue this treatment for a month, when the splints may be removed, and a slight angular movement may be permitted. If this is not very gently and gradually done, there is great danger of rupturing the newly-formed fibrous union which has already taken place, and the consequence might be, that the perfect extension of the limb would eventually be lost. In fractures of the olecranon, the little vascularity of the part, and the rupture of the periosteum, as well as the distance of the fractured surfaces of the bone, contribute to prevent the formation of callus and the reproduction of osseous matter; the union is thus effected by a ligamentous tissue, and even this tissue is often deficient in uniformity; for when it was of considerable length, Sir Astley Cooper observed several apertures.

The power of extension of the limb diminishes as the length of ligament increases; or, in more precise language, the power of extension is inversely as the length of the ligament. This is very apparent from the structure of the joint, the nature of the motion, and the action of the triceps muscle.

In fracture of the external condyle of the humerus, a crepitus may be easily detected by a rotatory motion of the radius on the ulna. When the fracture is considerable, the condyle is drawn slightly backwards, and carries with it the head of the radius. In the treatment of this fracture, a bandage is applied around the elbow, and extended above and below the joint; an angular splint to receive the elbow and to support the fore-arm in a flexed position (retained by a bandage) is then applied. This apparatus is worn about three or four weeks, when it may be removed, and a slight motion at first allowed, to be gently increased until union is maturely established. When the whole of the fractured portion lies within the capsular ligament, Sir Astley Cooper states that he "has never seen it repaired by osseous union."

The patella is the last of this series of bones the fractures of which belong to the class of those incapable of, or of difficult osseous re-union. The patella is sometimes broken transversely by the action of the powerful muscles which extend the leg; it is also often broken by falls and other kinds of blows; indeed, its situation is such as to expose it to a variety of accidents which may produce fracture of the bone. When the patella is broken across, the superior portion is drawn upwards by the extensor muscles of the leg, while the inferior segment is retained in its position by the ligament by which it is connected with the tubercle of the tibia. The distance between the fractured surfaces depends on the degree of laceration of the ligament; this distance varies from half an inch to five inches. The detection of the nature of the injury is not difficult, as the depression of the surface over the normal seat of the bone, and the ease with which the finger may be passed between the broken surfaces, together with the loss of power to extend the limb and to support the body on the leg affected in standing, will enable the surgeon at once to determine the nature of the accident. There is but little pain attendant on this injury; but inflammation, swelling, and effusion of blood soon come on, which give the part a livid ecchymoid appearance. This state of the part is generally accompanied with some febrile symptoms. From the great distance of the fractured surfaces from each other no crepitation can be obtained, nor indeed should be anticipated, unless the fractured portions of the bone could be brought into contact. In the treatment of this fracture, the limb is placed on a hollow, straight splint, in the extended position, the trunk being raised in order to relax the rectus muscle. The upper portion of the bone is then pressed down into contact with the lower portion, or as far as it can be accomplished without violence, and it is to be retained in this situation by a roller or strap passed round the limb immediately above the upper margin of the patella, and drawn downwards by a strap from each side passing down the leg and under the foot, care being taken to depress the upper segment of the patella should it project forwards from the pressure at its base. During the inflammatory and swollen stage, the application of leeches and evaporating lotions may be required, and care must be observed that in this state of the limb it is not bandaged too tightly, as this would be productive of great irritation and probably sloughing. The time necessary to keep the limb in position, in order to allow a reunion of the bone, is about five or six weeks, when a gentle motion may be induced, and increased gradually until the requisite range of motion is acquired. It is of great importance to render the union as perfect as possible. This mode of union is generally, if not always, fibrous, and there is sometimes a space of two or three inches, after the treatment, between the fractured segments. The greater the distance between the fractured ends of the bone, the less is the security and facility in walking. Cases, however, occur in which the patient manages to walk tolerably well, although the distance between the broken surfaces may allow the finger to be passed between them. When the patella is fractured longitudinally, the union is more easily accomplished, as the muscles which draw the transverse fractured segments asunder have a tendency to keep the longitudinal segments together. But even in this case the fracture is usually united only by fibrous tissue.

This completes the series of bones, the fractures of which are said to be repaired only by fibrous union. It has, however, been seen that the head of the femur may be united by bone, and the same might be suspected of the rest. I consider it still more probable, since the approximation, or at least the near approximation, of the surfaces of the rest may be more susceptible of being secured and retained in position. In corroboration of this view it is said that the late Mr. Clift, of the Royal College of Surgeons, had the fractured olecranon process united by bone. Enough, however, has been demonstrated to show that the theory of Sir Astley Cooper, respecting the osseous re-union of the bones, which has been already disputed by Larrey, Dupuytren, and other surgeons, cannot be any longer sustained, and it is liable, as has been already stated, to have an injurious tendency in practice.

With regard to the difficulty of forming a correct diagnosis of the existence or nature of fractures, some tact and experience are necessary. Every surgeon is supposed to be sufficiently acquainted with the symptoms attendant on every special case to discriminate between those cases in which crepitation is likely to happen, and those in which it is impossible, to be able to distinguish by the symptoms a fracture from a dislocation, and to discover whether either one or both exist together, or whether they exist at all. It might be deemed superfluous to mention these circumstances, but unfortunately these observations are by no means so unnecessary and uncalled-for as might be supposed. We often meet with instances of great mistakes made in attempts to discriminate between dislocations and fractures, and other injuries of the limbs. Amongst the cases of difficult diagnosis may be especially classed fractures of the base of the skull. To determine the special nature and extent of the injury, and to discriminate between these fractures and concussion of the brain, is often a matter of extreme difficulty. For example, a man falls from his horse, or some other height, to the ground on his head; he is taken up in a state of insensibility, the blood gushing from his ears. The question we ask ourselves is—"Is there any fracture, and if so, what is the seat and the nature of the injury?" In this early stage it is very difficult to answer correctly at once, and even afterwards until consciousness returns, and the symptoms indicate the real effects of the accident. Fortunately, very little can be done in this state beyond placing the patient in the horizontal position, and keeping the head quiet and cool, until symptoms arise requiring further attention. Sometimes a diagnosis of the bones implicated in the fracture may be deduced from the nerves of the head which happen to be paralyzed.

Mr. Hilton, in a lecture which has been lately published in "Guy's Hospital Reports," enters into a minute anatomical description of the structure of the cranium, with reference to the power of the several parts in conducting and stopping the vibratory movements generated in the bones of the skull. He is of opinion that it is the vibrations of the skull that destroy life in some instances of fracture of the base. He observes, "I have known it to happen, that a person having been exposed to external violence, which has led to a fracture of the base of the skull, and feeling pretty well a few days after the accident, has expressed a desire to get up and leave his sick chamber, which his medical attendant has been indiscreet enough to allow him to do, or which he has done of his own accord. After moving and walking about, however, for a short time, he has soon complained of headache; has been attacked with sickness and vomiting; afterwards has had a confusion of his ideas, and, finally, has fallen into a state of unconciousness, in which, after three or four days, he has expired."

The explanation of these symptoms, he observes, "I believe to consist in the interference which the fracture has produced, or the interruption it has occasioned to the natural course and termination of the cranial vibrations."

This explanation seems to me to be perfectly untenable; for why should the vibratory motions caused by walking produce death? and is it not more rational to ascribe the fatal termination to the pressure of the head on the fractured base, and the force of the percussions produced on it by walking in the erect position?

The mechanical injuries of the shoulder-joint rank amongst those which are the most liable of any portion of the human body to be mistaken in practice by the surgeon. If we consider the several parts which enter into the mechanism of the shoulder; its highly-artificial connexion with the rest of the body; its projection on the trunk in space; the numerous muscles acting in all directions, which retain it in its position, and produce upon it a variety of movements; and its intimate connexion with the movements of the arm,—we need not be surprised that the injuries of the shoulder-joint should present complexities of a nature to render a correct diagnosis extremely difficult. The shoulder-joint is often subject to severe contusions, accompanied with great swelling of the joint, rendering the motion of the arm very painful. Dupuytren mentions several cases of contusions which were mistaken by hospital surgeons, and treated for fracture of the humerus; but the absence of crepitation, and the rotation of the head of the bone with the rest of the arm, should have been sufficient to prevent a mistake in such a case. The clavicle being the only bone that connects the shoulder-joint with the thorax, and being a bone naturally curved and of slender make, is the bone by far the most common to be fractured in falls on the joint of the shoulder. From its superficial location, the diagnosis seems almost impossible to be mistaken. This, however, is not always the case—for instance: I was called to the case of a coachman, who had fallen from the driving-box of a carriage to the ground, pitching on the shoulder. Two surgeons had been already called in, one of whom pronounced the case to be a fracture of the humerus, and the other a fracture of the neck of the scapula. Upon this, a dispute arose, and they both left the patient without doing anything upon either hypothesis. On examination, I found that the shoulder-joint was quite sound, but that there was a fracture of the clavicle. It is surprising that such mistakes should occur in cases where the diagnosis is so easily obtained. Indeed, had not I personally witnessed the fact, I should hardly have imagined that such mistakes could have arisen. When the neck of the humerus is fractured, a diagnosis is obtained by the head of the humerus being held firmly in one hand, while the arm is rotated by the other. In this way it will be found that the head of the bone will remain stationary while the shaft rotates. These motions cannot happen except in fracture of the neck of the humerus. Sometimes the neck of the fractured humerus is found driven into the axilla, and in this situation has been occasionally mistaken and treated for dislocation of the head of the bone.

When the acromion process of the scapula is fractured, the accident may be easily distinguished from dislocation of the head of the humerus; for on placing the hand on the acromion process, and rotating the arm, a crepitation can be felt at the point of the shoulder; the shoulder-joint is depressed, and the patient can raise the arm only partially, and with great difficulty. But it not unfrequently happens that the same kind of force which fractures the acromion, will, when differently directed, fracture the neck of the scapula. This may be easily distinguished from fracture of the acromion, as we can feel the hollow below the acromion, produced by the sinking of the head of the humerus in the axilla. It may also be distinguished from dislocation of the head of the humerus by the mobility of the arm, and by the crepitus produced during the rotation of the humerus.

In compiling these lectures I have endeavoured to condense as much of the present state of our knowledge on the several subjects introduced, as the compass of these lectures would permit; and, independently of the original researches which they contain, I have collected materials from the latest and most esteemed writers on the subject. In doing this I am particularly indebted for many practical observations to the works of Sir Benjamin Brodie and Mr. Stanley, and to the elaborate researches of Professor Rokitansky, whose descriptions of pathological changes in the bones appear to be of unrivalled accuracy. At the same time, I am sensible of having treated many of the subjects in mere outline, touching only on their prominent points; but this seemed unavoidable in a course of only three lectures, as minute details of any one subject would have consumed the whole time allotted for their delivery; but I trust I have succeeded in putting them into such a form as will be most acceptable and useful, and I hope that the subjects introduced have been of such a nature, and have been treated in such a manner, as the Society expect to obtain from those on whom they confer the trust and honour of delivering the Lettsomian Lectures.

THE END.

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