ON THE
ABSORPTION OF DEAD BONE.

BY
WILLIAM SCOVELL SAVORY, F.R.S.,
ASSISTANT-SURGEON TO ST. BARTHOLOMEW'S HOSPITAL.

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CAN dead bone be absorbed? One is almost tired of the question. Still, it must be asked until it can be answered. Notwithstanding all that has been done on the subject the reply remains doubtful, for while, on the one hand, the most careful and accurate experiments, such as those of Mr. Gulliver, recorded in the twenty-first volume of the *Medico-Chirurgical Transactions*, have furnished only negative results; on the other hand, there are unquestionable facts, such as the absorption of ivory pegs when driven into bone, which compel us to admit the possibility of the occurrence.

In reflecting upon this evidence, thus apparently contradictory, it seemed to me that one all-important consideration had been neglected in the inquiry—the influence of *pressure* in determining the result. Thus, in the experiments which have been performed on the subject, and which have naturally led to the conclusion that dead bone may be kept amidst living tissues for weeks or months without losing the merest fraction of its weight, in these experiments the dead bone was kept in simple contact only with living parts; it appears that no considerable pressure was

maintained, whereas when ivory pegs are driven into bone extreme pressure is, of course, produced. In order to test this view, the following experiments were performed.

Experiment 1.

The outer surface of the right tibia of a young ass having been exposed by a short incision, a hole was drilled into it, and into this a peg, made out of the compact substance of the shaft of a human femur,¹ was very loosely inserted. The incision was then carefully and completely closed by silver sutures.

The corresponding part of the left tibia of the same animal having been exposed in like manner, a similar hole was drilled into it, and into this a peg, made of the same bone, was tightly hammered. The incision was then closed by silver sutures.

Eighteen days afterwards the pegs were examined. The wounds had suppurated, and were partially closed. The peg which had been loosely placed in the right tibia was in no way altered; its whole surface was still perfectly smooth. The peg which had been tightly hammered into the left tibia was visibly affected. The surface was roughened from the removal of very thin layers of bone in irregular patches.

After death the bones which had been operated on were found to be acutely inflamed. Upon section, the medullary membrane and cancellous tissue were of a bright-scarlet colour; even the compact texture was of a pinkish hue. In one case the greater portion of the medullary membrane was in a sloughing state.

Experiment 2.

The outer surface of the femur of a young rabbit having been exposed by a simple incision over it, a hole was drilled transversely through the shaft, and into this a conical peg

¹ In all these experiments the pegs and plates employed were made out of the compact substance of the shaft of a human femur.

was passed as far as it would go, its larger end being firmly impacted, while in the rest of its extent it lay comparatively free. The wound was closed by silver sutures, and soon completely healed.

At the end of six weeks the rabbit was killed. The peg was found exactly as it had been placed. All traces of disturbance in the surrounding parts had quite passed away. When the peg was extracted it was visibly corroded at the part which had been subjected to pressure.

Experiment 3.

The right femur of a young rabbit having been exposed, a small plate of bone was loosely attached to it by thin copper wire passed around them. The wound was then closed.

To the left femur a similar plate of bone was firmly secured by copper wire passed around them, and twisted up so tightly as to press the opposed surfaces forcibly together. The wound was then closed.

Both wounds suppurated for some time, and at last healed. The rabbit continued to be quite healthy, and increased rapidly in weight. At the end of six weeks it was killed.

When the skin was reflected, each plate was found imbedded in a mass of inspissated pus, which was invested by a thin, transparent, but well-defined, capsule. The plate which was loosely connected was not perceptibly altered, but the surface of the plate which was firmly pressed against the bone was in part corroded.

Experiment 4.

The front surface, towards its lower end, of one femur of a healthy young rabbit was exposed by a simple incision, and a hole was drilled through it. Through this a peg, which weighed eight grains, was hammered so as to transfix the bone.

A similar operation was then performed on the other femur, with this exception, that the peg, which also weighed eight grains, and was tightly hammered in, did not pass completely through the bone.

Both wounds were thoroughly closed by a continuous silver suture, and soon completely healed.

Five weeks and two days afterwards the rabbit, which did not appear to suffer materially from the operation, died. During the last fortnight of its life it had gradually lost flesh.

The external wound had been long closed. A large abscess was found around each peg in front of the femur, consisting of inspissated pus in a distinct and well-formed cyst. The pegs, which had been driven in, were firmly implanted. It required considerable force to draw them out.

The portion of each in contact with the bone had been obviously acted on. The surface was much roughened from removal of the superficial portion by absorption. The peg which had transfixed the bone had lost a grain of its weight, and the other almost as much.

Experiment 5.

The outer surface, towards the lower end, of the left femur of a healthy young rabbit was exposed by a simple incision, and a hole was drilled completely through it. Through this a conical peg, which weighed twelve grains, was tightly hammered so as to transfix the bone and project about the sixth of an inch beyond.

The front surface of the right femur, towards its lower extremity, was then exposed, and a thin plate of bone, weighing five grains, was secured in firm contact with it by means of copper wire passed around the femur, the ends of which were tightly twisted together over the plate. To increase the pressure, a conical peg of bone, weighing four grains, was afterwards pushed under the wire.

Both wounds were thoroughly closed by a continuous silver suture, and soon completely healed.

Seven weeks and three days afterwards the rabbit died. For the first six weeks it appeared to be well and lively, then it gradually lost flesh and strength.

Both external wounds were completely healed. An enormous abscess, in a distinct sac, was found around the peg in the left leg. A smaller abscess invested the plate in the right limb.

The peg in the left femur was firmly implanted, and it required some force to extract it. The portion which occupied the hole in the bone was obviously affected. The surface was much roughened from loss of substance. The portions projecting beyond were in no way altered. To one part of the peg a small thin plate of bone adhered very firmly. This was a portion of the posterior wall of the femur which formed the boundary of the hole. The connection between the fragment of bone and the peg must have been very intimate, for when the peg was extracted they not only came away together, but afterwards they resisted considerable force which was applied to separate them.

The plate and peg were found tightly bound to the other femur by the copper wire, which now appeared to pass beneath the periosteum, as if this membrane had grown over it. Around the edges of the plate some new bone had been, as it were, heaped up. When the plate and peg were removed, their surfaces were still quite smooth. They did not appear to have been affected in any way.

It is very difficult in this way, or in any other that I could devise, to maintain any considerable amount of pressure, or pressure at all corresponding to that which is obtained by driving a peg into bone.

Experiment 6.

The front surface, near the lower end, of the left femur of a healthy young rabbit was exposed, and a hole was drilled through it. Into this a peg, which weighed four

grains, was thrust. It accidentally produced fracture of the femur across the hole. The peg was left lying loosely between the ends of the fractured bone, and the wound was closed by a continuous silver suture.

A similar hole was made in the corresponding part of the right femur, and a similar peg, of equal weight, was tightly hammered in. The wound was then closed in like manner.

The rabbit continued apparently well for some time. Then around either femur a large collection of pus formed, and eight weeks and four days after the operation the rabbit died.

Both external wounds had been long before death completely healed.

There was an enormous collection of pus around the left femur, and in the wall of the cyst which contained it the peg was found imbedded, having evidently been carried out away from the bone. It had undergone no change of any kind. There was no repair of the fractured bone.

A much smaller collection of pus was around the right femur. The peg was found loose in the hole, for this had been drilled at the junction of the epiphysis with the shaft of the bone, and the peg, driven in, had caused their separation. Thus it lay loosely between them—there was no reunion—and had not undergone any change whatever.

Experiment 7.

A hole was drilled through the lower part of the shaft of the left femur of a healthy young rabbit, and into this a peg, which weighed four grains, was loosely inserted. The wound was closed by a continuous silver suture, and soon healed throughout.

A similar hole was drilled into the corresponding part of the right femur, and a peg, of the same weight, was loosely inserted. While the wound was being closed the bone was accidentally broken across the hole. This, however, was soon repaired, the wound having been completely united.

Three days after, the left femur was accidentally fractured at the seat of the operation. This was subsequently repaired, with an abundant formation of callus.

After a few days the animal regained its health, and remained as well as if nothing had been done.

Three months after the operation the rabbit was killed. In the left leg the peg was found lying imbedded on the surface of a large mass of callus. It was in no way affected. When it was removed, a deep groove, which formed almost a complete canal, appeared on the surface of the callus.

In the right leg the peg was found unaltered, lying loose in a well-formed capsule of connective tissue on the muscles of the thigh under the skin.

There was no trace of abscess, or of any other disturbance of the surrounding parts, in either leg.

Experiment 8.

A hole was drilled through either femur of a healthy young rabbit, and into each a peg, which weighed four grains, was tightly inserted.

The wounds were closed, and soon completely healed, and the animal quickly regained its usual health and condition.

It was killed three months after the operation.

When the left leg was dissected the peg was discovered as it had been placed, transfixing the bone, and standing out about two lines from its front surface. When a gentle attempt was made to withdraw it the projecting portion came away from the rest with very slight perceptible evidence of fracture. There was a ridge of new bone around the orifice.

When a section was made of the femur through the hole, it was evident that a considerable portion of the peg had disappeared, and its now irregular outline could be only imperfectly traced across the shaft, for they seemed to be at some parts continuous. The outline of what remained of the peg could not be defined from the adjacent portion of bone. There was an increased formation of osseous tissue

around, for the margins of the hole were denser in the compact part, and a wall of new bone extended around the remaining portion of the peg across the canal.

In the right leg a very similar state of things was found. The peg was in part absorbed, and the remaining portion appeared upon section to have become here and there blended with the bone. New bone, which was softer than the old bone, was thrown out around the peg, and extended across the canal.

Not only was there no trace of abscess or of any disturbance of the surrounding soft parts in either leg, but the repair was evidently as perfect and complete as possible. The projecting portion of either peg was invested by a capsule of connective tissue.

Experiment 9.

A peg, which weighed four grains, was tightly hammered into a hole drilled into the femur of a young rabbit. The wound was closed, and healed throughout, and the rabbit remained well.

Three months afterwards it was killed.

The peg was found firmly implanted in the bone, and apparently continuous with it. New bone was deposited around the hole, extending from the adjacent surface of the femur upwards on to the peg, where it was gradually lost. There was no trace whatever of any surrounding disturbance.

The bone was not at once divided, as in the last experiment, but was previously macerated.

When a section was made of the femur through the part into which the peg had been driven, very little of the peg could be seen. It had almost entirely disappeared. New bone had been deposited around, so as to form, as it were, a shell, which enclosed all that remained of the peg.

It appears to me that the only explanation which can be offered of the results of these several experiments is that

the absorption of dead bone, when in contact with living bone, is determined by the pressure to which it is subjected.¹

It is but reasonable to believe that what great pressure may effect in a short time less pressure may accomplish in a longer time.

In some of these experiments, as in the last two, it seems as if absorption of the dead bone goes on only so long as pressure is kept up, while at the same time the irritation produced by its presence is followed by an increased formation of new bone around, which is so closely and accurately adapted to the rough surface of the remaining portion of the dead bone that the line of junction is almost lost.

While, therefore, the possibility of the absorption of portions of sequestra² under rare conditions must not be

¹ "The possibility of the absorption of dead bone seems amply proved by cases in which portions of pegs of ivory, driven like nails into bones, to excite inflammation for the repair of ununited fractures, have been removed. The absorption, I say, seems amply proved; but the method of it is made, by the same observations, more difficult than ever to explain; for only those portions of the ivory that were imbedded in the bone were absorbed; the portions that were not in contact with bone, though imbedded in granulations or pus, were unchanged."—Paget. *Surgical Pathology*, vol. i, p. 472, note.

² Hunter says, speaking of the separation of dead bone—"I by no means wish to be understood that no absorption of the dead piece can take place, for, on the contrary, I believe that nature sometimes finds it necessary to the completion of her process; it generally takes place when the separation is slow and the granulating process is quick. This absorption of dead bone takes place in the fangs of the shedding teeth."—*Works*, vol. i, p. 527.

"Examples of necrosis show that, in the large majority of cases, the separation of dead bone is accomplished entirely by the ulceration or absorption of the living bone around it; but that, in certain cases, especially in those in which pieces of bone, though dead, remain continuous with the living, the dead bone may be in part absorbed, or otherwise removed, not, indeed, in mass, but after being disintegrated or dissolved."—Paget. *Surgical Pathology*, vol. i, p. 472.

There are cases on record in which dead bone has disappeared without any sensible exfoliation of it. See, for examples, Stanley on Diseases of the Bones, p. 90, &c.

denied—for it cannot be maintained that living parts exercise no influence upon dead bone under any circumstances—the fact that such a result is hardly ever accomplished is easily explained.

It is generally understood that, under certain circumstances, the absorption of living bone may be effected by continuous pressure;¹ for example, we all are familiar with the disappearance of large portions of the bodies of vertebræ by the extension against them of aneurismal and other tumours. But in my experiments there was no satisfactory evidence of the absorption of living bone by the pressure of dead bone.

While, then, the great influence of constant and continued pressure in producing the absorption of living structures is a recognised fact, it may hereafter appear to be at least as important in effecting the absorption of dead ones.

¹ “Bones admit of every mode of absorption that the soft parts do. The most common cause of absorption in them is pressure. Whatever makes an unnatural pressure gives a stimulus for the removal of the bone.”—Hunter's Works, vol. i, p. 500.