there has been no discharge whatever between the grafts, although I had regarded them as very unsuitable cases before the application of flaxine.

2. The grafts should not be covered with any dressing and should properly protected. At the suggestion of Dr. Culverwell I have used inverted boxes of various sizes and shapes cut to fit the contour of a limb if necessary. A jeweller’s or instrument maker’s cardboard box is the most suitable. The edges should be slightly padded, and the box should be ample large, so that there is no risk of the peduncle touching the wound.

3. The technique I have used is as follows: The surface from which the skin is to be taken is prepared in the usual way. The wound is covered with a simple guaze dressing, and when this is removed care is taken to disturb the surface as little as possible. Two razors are employed, so that one can be dipped into boiling water while the other is being used; thus the freshly cut surface heals without any suppuration. The grafts are cut about the size of a postage stamp, and with practice can be cut to almost any shape. The skin and razor are kept thoroughly wet with normal saline, so that the grafts can be more easily cut and removed from the razor. The graft is conveyed to the wound on the razor, and slipped off with the help of a blunt probe. The grafts are generally placed about one-eighth of an inch apart, but can be closer together in a very clean wound. The box, sterilized beforehand, is adjusted to the part and fastened down by long strips of rubber plaster; the ends of these are thoroughly bandaged, the bandaging being brought up to the box as close as possible on all sides, but not over it. As a further safeguard against any chance of slipping the bandage is always used in the form of a spike whenever possible. It is then pinned to the box with a liberal supply of safety-pins. The box remains quite firm for three or four days, when it can be removed. The grafts are then found to be firmly fixed, and any dressing, such as fomentations or red lotion, can be applied.

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ON

THE ANATOMICAL AND PHYSIOLOGICAL PRINCIPLES UNDERLYING THE TREATMENT OF INJURIES TO MUSCLES, BONES, AND JOINTS.

GIVEN AT THE ROYAL COLLEGE OF SURGEONS OF ENGLAND, NOVEMBER-DECEMBER, 1917.

BY

PROFESSOR ARTHUR KEITH, M.D., F.R.S., CONSERVATOR OF THE MUSEUM.

IV. THE INTRODUCTION OF TENOTOMY:

The events which led to the introduction of tenotomy as a measure of surgical routine had nothing to do with Hunter’s experiments; they occurred nearly thirty years after he was dead.

The man who can best serve as a guide, as we follow the march of events, is William John Little, the son of farmers living in comfortable circumstances in the East End of London. Little was born in 1810, and was therefore a contemporary of Hilton. In his infancy he suffered from a fever which left the extensor muscles of his leg (so he informs us) paralysed. As he grew up his left foot became inverted, the heel raised, and a typical talipes equino-varus developed. At the age of 15 he was apprenticed to a neighbouring apothecary, but two years later, in 1828, his indenure being cancelled, he began the study of medicine at the London Hospital. He entered his studies with the fixed intention of discovering what could be done for the relief of such a condition as he found. He found that club-foot was regarded as lying outside the legitimate scope of surgery, and, in the opinion of his teachers, was properly confided, as his own case had been, to the care of homosectors and sprain robbers, who treated the condition with manual instruments, often with a fair degree of success. A man whose chief object in devoting himself to medicine had been the alleviation of a personal infirmity—one with which his senior contemporaries Lord Byron and Sir Walter Scott were afflicted—was not likely to remain content with the comfortable promises of his time. All through his time of study at the London Hospital he sought every opportunity of making himself acquainted with the actual condition of patients with feet; he had a facile command of the French tongue; and during his student-life followed medical progress in the literature of Paris as well as in that of London. He became particularly interested in the work of Delpech of Paris, who had described and carried out what he called the operation of Achilliss for the cure of club-foot. When he had passed through the curriculum of his own hospital he went to study in the post-mortem room at Guy’s Hospital, under Dr. Robert Grant at University College Hospital (1834) that he settled to a city practice in Billiter Street, and was appointed lecturer on comparative anatomy and physiology at his own hospital—the London. In 1834, having been 24 years of age, he became Member of the College, but in that year was his failure to obtain a vacant assistant surgeoncy at his hospital. He therefore resolved, as is not unusual under such circumstances, to become a Licentiate of the College of Physicians, and devote himself to medicine. For that purpose it was necessary for him to spend two years at a university. He chose Berlin, drawn thither by the great fame of Johannes Muller. In 1834 we see this lame and somewhat insensitive Englishman set forth for Berlin armed with a letter of introduction to Muller from Grant. The note is signed by the professor of anatomy, which accorded to him because of his office of lecturer in comparative anatomy. When Little entered Muller’s laboratory he found there Schwann, Henle, Remak, and the other young men, whose work would reveal the cellular constitution of living matter. Little had every opportunity given him in Muller’s laboratory of continuing his dissections of deformed feet. The condition revealed by his dissections supported the conclusions he had drawn from a series of investigations in England—namely, that surgeons were in error in believing club-foot to result from an inherent defect in the growth of the bones of the foot; the cause of the deformity lay in the soft parts—particularly in a disordered action of the muscles, with that conclusion Muller agreed with Little in regarding the condition as one which should be amenable to surgical treatment.

Before leaving England Little had read of a young surgeon at Hanover, Stromeyer by name, who had modified Delpech’s operation, and was cutting the tendon Achilles for the rectification of club-foot. Müller agreed with Little that such an operation had a rational basis. Hence we find Little, in the summer of his second year of study in Berlin, and the twenty-sixth year of his age, visiting Stromeyer in Hanover.

Stromeyer was only six years Little’s senior. He was born in Hanover in 1804, the son of a surgeon there who had strong leanings towards the art as practised in England. After spending almost a year in England, studying for a year in Edinburgh, he commenced practice in his native town in 1828. From the outset of his practice Stromeyer applied himself to the treatment of physical disabilities and deformities. He fitted out a small private hospital, but found the establishment of the kind of practice he desired an uphill task. In 1831 his opportunity came. The son of a local schoolmaster, a boy of 14, was the subject of club-foot—intractable, painful, the despair of his relatives and medical attendants. Stromeyer gave the lad a bed in his hospital, and settled down to give his case eighteen months of unremitting attention and care. As a last resort, he cut the tendon Achilles by a new—a subcutaneous—method; lifted that the foot could then be flexed (dorsiflexed) and that the cut ends of the tendon were separated by four quarters of an inch. The gap evidently frightened him somewhat; at least he again extended (planatar flexed) the foot until the ends were in apposition, before he fixed it in position. At the end of six days he “proceded” finding the foot that the cut ends of the tendon did not separate, but moved together. He gradually dorsiflexed the foot, thus, as he supposed, stretching the scar in the tendon, so that in eight weeks the heel was brought down to a proper level and all the symptoms of the case were removed. Stromeyer ascribed his success, not to the eighteen months of unremitting attention he had given to the case, but to the operation he had thus introduced into surgery. Tenotomy, he declared reduced the
time necessary for the cure of club-foot from months to weeks. It brought hope and healing to a neglected class of cases.

He believed that the great truth he had discovered, which has still to be insisted on—"that the theory of congenitalism which had been so consistently applied to a certain class of deformities was a curse to surgical progress; it was used to cover ignorance and, when applied to club-foot, produced surgeons from inquiring into the nature, origin, and ultimate cure of the condition. Nature, he said, could not cure club-foot; it could only make the condition worse. Heat and rubbing, he found, were useless in mending spastic or contracted muscles. He regarded club-foot, therefore, primarily as a condition with a predisposition to a disordered action of the muscles of respiration. Section of a tendon, he believed, not only relieved the tension of a muscle, but also, as Hunter had concluded, altered its function in the body. He observed that a spastically contracted muscle, when its tendon was cut, passed into a condition of rest. Tenotomy he regarded as a means of giving rest to an inflamed joint. He saw how tenotomy could be profitably applied to many regions of the body; how it could be used as a cure for spasticism, and not only a cure for deformities—it gave the surgeon an opportunity of directly affecting the disordered action of a muscle.

Such was the condition of matters when Little entered the medical school at Hanover in July of 1836. There he had his deformity rectified; numerous opportunities were given of perfecting himself in the technique of the new operation; he returned to Berlin convalescent and ready to inaugurate a new era in the treatment of club-foot. He showed himself to Müller and to Müller's colleague, Diefenbach, the surgeon; they were amazed at the success of the Stromeyerian methods. Diefenbach put them in practice almost immediately; in the course of a little over a year, 180 cases of club-foot were operated on and it was found that it was necessary to rectify the deformity rapidly at the time of operation to the slow post-operative reposition practised by Stromeyer.

Little read his thesis for the doctorate of Berlin University on the nature and treatment of club-foot, and early in 1837 returned to London and at once settled down to treat cases of club-foot. His enthusiasm compelled the attention of his medical colleagues; some were interested, others were skeptical, many were grieved. Although of a retiring, modest nature he proved to be the right man to lead a crusade. In 1838, with the help of relatives and friends, he succeeded in establishing the Orthopaedic Institution—afterwards the London Orthopaedic Hospital—the first of our public institutions for the relief of the maimed and deformed poor. Into the labours of that institution he threw his full strength. In 1839 he published a treatise on The Nature and Treatment of the Deformities of the Human Frame. He was asked by the medical profession to give lectures to students on the orthopaedic treatment of deformities; he published the course he gave in 1843-44 under the title of The Nature and Treatment of the Deformities of the Human Frame.

There is no doubt that the point of section of the saphenous nerve was the peculiarity of orthopaedic surgery in England. He regarded subcutaneous tenotomy as a great discovery—a surgical revolution. If in this he was too sanguine he at least focussed attention on the treatment of deformities, and particularly on muscles and tendons. He gave evidence that his influence and labour made themselves felt in London and Edinburgh. In 1839 James Paget, then a young man of 25, walking at St. Bartholomew's Hospital for an appointment on the staff, was moved to investigate the repair and blood supply of tendons. He found that he was supplied with a double supply, (1) from the arteries of the muscle, and (2) from the arteries of their sheath. If a tendon were cut, both these supplies took part in furnishing the cut end with blood supply. He found that when a tendon was cut in long strips sufficiently wide to prevent the adjacent synovial sheath from forming a synovial sheath, that repair depended on the blood supply. Paget began to practise the operation of tenotomy. He cut tendons in deformed feet and almost immediately turned patients out of hospital to let Nature complete the cure; we now know that in such cases she performs her part very ill.

On Little's return to England he became a Lecturer of the College of Physicians, and in 1840 was appointed assistant physician to the London Hospital, but the College did not look on his surgical discoveries with a favourable eye, and he was not a member of the College until in 1857 he became a Fellow. He also had his gains. It was his interest in orthopaedic surgery which drew him to the study of the disordered action of muscles and led to his recognition and description of the disordered action (Little's disease). His belief in the efficacy of tenotomy ultimately led him to think that a stretched muscle recovered better than one which had been tenotomized. He found him in 1876, as before, that the continuous care of the surgeon, the nursing and co-operation of the staff day by day, gave the best results, with an infinite expenditure of patience, which gave restoration of shape and function to deformed parts. In 1884 William John Little withdrew from active practice to live at Wall Malling, Kent, where he died in 1894. Stromeyer's career had come to an end long before the age of 70. His last years saw the result of his early enthusiasm for the orthopaedic movement to be tempered by an experience of forty years. He then realized that tenotomy might be a curse as well as a benefit. Tenotomy applied as the sole measure for the treatment of deformities might have disastrous results.

To see the principles which guided the practice of the men who followed in the orthopaedic movement started in England by Little, we shall follow the career of William Adams. When Little returned from Berlin in 1837, his younger son, a lad of 17, had just been taken to him by his father, a surgeon in Finsbury Square, in the city of London. He joined St. Thomas's Hospital as a student, working under Hodgkin and Green, and after four years was made a Member of this College in 1842. By that time the orthopaedic movement started by Little had failed. At Hodgkin's suggestion Adams became curator of the museum at St. Thomas's Hospital and worked there at pathology, waiting for an appointment on the staff, trying to the same time to build up a practice in the city. In 1851, being then 31 years of age and seeking an appointment to his own hospital, he sought and obtained a place on the staff of the orthopaedic hospital founded by Little. We can see by the way he then set to work that he knew how scientific surgery should be built up. There was still a doubt as to the exact manner in which repair was effected after a tendon is cut. He carried out a series of experiments on sixteen rabbits, cutting the tendon of Achilles and reapplying each stage in the process of repair. His description of the surgical measures needed to be taken to the repair was complete and final. He then went on to see the results of his dissections of deformed feet in which the tenotomy had been carried out at varying periods before death occurred from some accidental cause. In one case of tenotomy of the tendon of Achilles, he demonstrated that 2½ in. of new tendinous material had become inserted in the course of repair. In another foot, where the tibialis posticus had been cut with its synovial sheath behind the malleolus, he observed that repair had failed, and at the point of section of the saphenous nerve had become adherent to the bone. Adams afterwards made use of this fact to find the best sites for the incision of the parietes—bones, joints, ligaments, and muscles—which had to be dealt with in the rectification of deformities. He investigated particularly the conditions of the muscles, the action of the flexors and extensors, and the effects of the dissection of the saphenous nerve. In 1864 was awarded the Jacksonian prize of this College for his dissections and investigations. When, however, we seek for a deeper knowledge of the cause and prevention of deformities and the action of every opportunity to look beneath the surface and obtain an accurate knowledge of the condition of the deep parts—bones, joints, ligaments, and muscles—which had to be dealt with in the rectification of deformities, we find that this searching investigation had to be effected by the application of rigid machines. In 1871 Adams introduced a subcutaneous operation for the relief of ankylosis of the hip-joint. We see in that operation the application of the subcutaneous method to osteotomy. He had applied to the hip-joint a method which had sprung out of the practice introduced by...
MEMORANDA

[DEC. 29, 1917]

Stromeier. Subcutaneous osteotomy, however, had been practised in Germany long before the date at which Adams applied this method to the hip-joint.

THE LAW OF LIGAMENT.

When we examine the principles and practice of Stromeier, Little, and Adams, all of them pioneers in orthopaedic surgery, we are struck by the importance they attach to ligaments in the production and treatment of deformity; ligaments seemed to them almost as important as bone. Even now the essential function of ligaments is misunderstood, and so long as this is the case we cannot hope to effect an object which is quite as important as the rectification of deformities—namely, their prevention. Hunter’s teaching as regards the respective function of muscular and ligamentous parts in the mechanism of the human body is very definite. Muscle is the only tissue of the body which can be applied for the continued support of parts without undergoing elongation. A ligament cannot perform that function because it is composed of living passive tissue which must stretch when it is submitted to continual tension. Nature never uses ligaments either for the purpose of passive support or of active maintenance of parts in position; she uses them only for the purpose of limiting movements of the muscles which guard and surround a joint are forced beyond the compass of their normal reach.

This law can be best illustrated at the shoulder-joint. In paralyses of the shoulder muscles, or when a patient is deeply anaesthetized, the ball of the humerus drops away from the glenoid cavity under the weight of the arm; the shoulder-joint can then be moved far beyond its normal limits; the ligaments become then the sole agents which limit movements and are subject to direct stress and strain. If, in the dissecting room, we strip the muscles from the shoulder and leave the humerus attached merely by its ligaments, we can see that in all normal movements they never become taut until the usual limits are exceeded. The real ligaments of the shoulder-joint, as of every other joint in the body, are the active defensive contractile muscles.

Now man’s upright position has made him more dependent on the ligamentous function of muscles than any other animal. His shoulders, when he stands up or sits up, have the muscular braces of our hip, knee, and ankle joints coming into continuous action. It is easy to demonstrate that the maintenance of the plantar arch owes nothing to ligaments; that can be demonstrated in the living foot and leg, and also in the dissected parts.

It is quite clear that ligaments are passive agents below elongation is not a cause but a consequence of the deformity. In short, all static deformities of the human body the cause has to be sought for, not in ligamentous changes, but in the disordered action of the muscles, and we shall never succeed in preventing oramel correct deformities until the truth of this law of the function of ligaments is clearly realized.

PROFLAVINE IN SEPTIC WOUNDS.

The following short notes of five cases of septal gunshot wounds of limbs treated with proflavine at the Kinaton Auxiliary Hospital may prove of interest to others engaged in military surgery:

CASE I.

Pte. O., aged 22. Gunshot wound of both legs on April 14th. Perforated left tibia; large lacerated wound of left leg, tibia exposed, piece cut away. May 25th, wound very septic; proflavine discarded. Worked for several weeks with saline and sequestre removed. Cavity packed with hirspaste. Temperature varying between 101° and 98°. On admission here on June 9th the wound was still in very bad condition. Dressings used, and wound improved to a certain extent, becoming cleaner. Proflavine was tried, irrigations of solution 1 in 2,000 in normal saline; thigh dressings and gauze packings through sinuses on inner side of tibia; the wounds were then covered with gauze saturated in the solution 1 in 1,000, and covered with protective. Dressed daily for ten days, then small vesicular rash appeared on surrounding skin. Saline dressings only were then applied. Previous oedematous condition of limb greatly improved, sutured on limb and skin remaining in position. Wound healed, and on August 10th sequestre separating. Temperature slightly raised at night, but patient’s whole condition improved.

CASE II.

Pte. O., aged 22. Gunshot wound of left leg on April 27th; large wound of inner side of left calf. Aponerosis of deep muscles exposed, Wound excised in France. On admission to Farnborough V.D. Hospital, the head of the humerus drops away from the glenoid cavity; the shoulder-joint could be moved far beyond its normal limits; the ligaments become then the sole agents which limit movements and are subject to direct stress and strain. If, in the dissecting room, we strip the muscles from the shoulder and leave the humerus attached merely by its ligaments, we can see that in all normal movements they never become taut until the usual limits are exceeded. The real ligaments of the shoulder-joint, as of every other Joint in the body, are the active defensive contractile muscles.

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Memoranda:

MEDICAL, SURGICAL, OBSTETRICAL

PROFLAVINE IN SEPTIC WOUNDS.

The following short notes of five cases of septal gunshot wounds of limbs treated with proflavine at the Kinaton Auxiliary Hospital may prove of interest to others engaged in military surgery:

CASE I.

Pte. O., aged 22. Gunshot wound of right shoulder on July 12th; large wound on back of shoulder, through deltoid muscle. Exposed bone left with proflavine pack, gauze running into the joint. Piece of metal present in upper third of arm. The wound was operated on at the casualty clearing station and Carrel treatment used. On admission here on July 26th the wound was very septic and discharging badly. There was slight rise of temperature at night. Sinses leading to base of scapula plugged with gauze saturated with 1 in 1,000 normal saline; dressing covered with protective tissue. Dressed daily for a week. There was a marked decrease in amount of discharge. Wound was dressed and treated with proflavine as above, for another week. Wound granulating; temperature normal, and the patient doing well.

CASE II.

Pte. F., aged 28. Gunshot wound of left leg on April 27th; large wound of inner side of left calf. Aponerosis of deep muscles exposed. Wound excised in France. On admission to Farnborough V.D. Hospital, the head of the humerus drops away from the glenoid cavity; the shoulder-joint could be moved far beyond its normal limits; the ligaments become then the sole agents which limit movements and are subject to direct stress and strain. If, in the dissecting room, we strip the muscles from the shoulder and leave the humerus attached merely by its ligaments, we can see that in all normal movements they never become taut until the usual limits are exceeded. The real ligaments of the shoulder-joint, as of every other joint in the body, are the active defensive contractile muscles.

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PROLONGED CATHETERIZATION.

A patient, aged 78, has just died after having catheterized himself regularly for fifty-seven to sixty years. At the age of 19 he was a very keen oarsman at Cambridge, and after great exertion in rowing had an attack of what was probably transverse myelitis. His legs were completely paralysed, and he was utterly unable to pass water. The legs gradually improved, and he was able to walk with two sticks. The bladder never recovered, and for fifty-seven years he passed a catheter regularly twice a day. He had repeated attacks of orchitis and cystitis. He told me that the urethra had grown so hard that no lubricant could be used, and that he never used any disinfectant.