STIMSON (L. A.)

THE TREATMENT OF FRACTURES OF THE HUMERUS INVOLVING THE ELBOW-JOINT.

BY

LEWIS A. STIMSON, M.D.,

PROFESSOR OF SURGERY, UNIVERSITY OF THE CITY OF NEW YORK; SURGEON TO THE NEW YORK HOSPITAL, ETC.

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THE TREATMENT OF FRACTURES OF THE HUMERUS INVOLVING THE ELBOW-JOINT.[1]

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THE special interest that belongs to the subject that has been allotted to me for presentation on this occasion arises from the frequency with which fractures of the lower end of the humerus are followed by more or less diminution of the functions of the elbow-joint, and by deformity of the region or of the limb. It therefore seems proper, and in keeping with the limited time at our disposal, that the discussion should turn mainly upon the causes of these unfavorable results and the means by which they can be best and most surely avoided. It is also assumed that in the selection of this subject for discussion before this Association, the members of which are so experienced and so thoroughly familiar with all its features, the intention was not to invite the expression of novel views, or the presentation of original observations, but to afford an opportunity for an expression of the collective opinion of the Association concerning the best methods of treat-

[1] Read at the meeting of the American Surgical Association in Washington, D. C., September 25, 1891.

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ment and the prognosis, and thus to supply a guide and protection for less favored members of the profession.

1. Causes of Limitation of Motion.—Permanent stiffness of the elbow after simple fracture is commonly due to a change in the shape of the articular surfaces, or in their relations to one another, that destroys the coincidence of the axis of curvature with that of motion, and thus limits the range of motion; or, to an overgrowth of bone upon the surface of the humerus that arrests the movement of the olecranon or coronoid process into its corresponding fossa; or, to a more or less extensive ossification of the ligaments and capsule.

As in flexion and extension the normal range of motion at the elbow is great, and since over a large surface the bones composing the joint are in close contact with each other, it follows that a comparatively slight change in shape or deviation of an axis may have a marked effect, and one that will be only partly relieved by the gradual yielding of the ligaments, or by the absorption of opposing bone under persistent stretching and pressure. It is like the defective "centering" of the hinges of a door.

Overgrowth of bone excited by the traumatism is much more frequent in the young than in adults, but so, too, are fractures of the lower end of the humerus, and in this overgrowth we find a cause of limitation of motion that, even if sometimes over-estimated because unreduced displacements are mistaken for it, is yet sufficiently frequent to merit serious consideration. This overgrowth is in part exuberant callus, and in part new bone formed beneath

the periosteum adjoining the line of fracture. Exuberant callus is usually formed when the displacement has been great and has not been well reduced, and the obstacles to motion created by it are, therefore, associated with others arising from change in the relations of the joint-surfaces; but it may occur even when the displacement is slight, as in one of my specimens, and in one possessed by the Charité at Berlin (Gurlt, II., p. 107). Overgrowth under the periosteum, extending to a greater or less distance from the fracture, is due to the irritation of the traumatism, and doubtless in part to the implication of the periosteum in the injury to the extent of its stripping-up in the displacement.

The frequency with which limitation of motion follows fracture, and with which it is due to each of these different causes, cannot well be established by statistics. Most of the cases are treated in dispensaries, and the ultimate result seldom forms part of the record. In the out-patient department of my service at the Chambers Street Hospital, which is probably the largest surgical dispensary in New York, receiving about 20,000 cases annually, there are treated each year some twenty cases of fracture of the lower end of the humerus, exclusive of the epicondyles. With a view of determining the relative frequency of the different forms of fracture and the character of the results, I have collated the statistics for the last six years. In a number of the cases some uncertainty arises through doubt as to the correctness of the diagnosis, but in general they show that fractures of the internal and external condyles taken together constituted nearly three-fourths of all, supra-condy-

lar and inter-condyloid, or T-fractures, the remaining fourth. Fractures of the internal and external condyles, when compared with each other, were of about equal frequency, although they differed so greatly in different years, and under different assistants, that errors in diagnosis seem probable. The supra-condylar and inter-condyloid were of nearly equal frequency, the former being rather the more frequent. The record of ultimate results is too incomplete to be of much service, as it ceases in most cases with a statement of the condition at the time of or shortly after the removal of the splints. In the inter-condyloid fractures flexion was then possible to, or slightly within, a right angle; of the others, in fully one-half no mention of the range of motion is made, while in those in which such mention is made it is usually described as "excellent," "perfect," or "good," and only rarely as "poor."

The specimens preserved in museums are few in number and serve only to establish the nature of some of the various causes. A search through the principal hospital collections of New York has yielded me only two. In one, a supra-condylar fracture, extension is prevented by a broad, flat osteophyte occupying the olecranon fossa; in the other—also supra-condylar, but with displacement—there is a broad mass of new bone behind, which is solidly united to the humerus and also to the tip of the olecranon process. A third specimen, one of fracture of the ulna at the base of the olecranon, shows another form of ankylosis—one by bony union between the opposing bony surfaces; I be-

lieve this form is rare, except after suppuration of the joint.

Upon these facts I make at present but one reflection, namely, that as limitation of motion may be caused by a bony outgrowth from the humerus, itself the result of a persistent displacement of a fragment or of the separation of the periosteum, the most efficient way to prevent it lies in an exact diagnosis and reduction of the displacement, and in the avoidance of any subsequent irritation of the periosteum.

A third cause of limitation of motion is found in thickening of the capsule and peri-articular tissues by the products of inflammation. The cause may act temporarily, during and for a limited time subsequent to the period of repair, or permanently by the production of new fibrous and cicatricial tissue, which forms abnormal bands connecting the different members of the joint and limits the extensibility of the peri-articular tissues and their mobility upon one another. As a temporary condition, its anatomical changes are presumably limited to an exudation that infiltrates the soft parts and wholly disappears with more or less promptness after the repair of the main injury and the consequent cessation of the irritation. Except in very rare cases under the influence of a constitutional dyscrasia, a permanent limitation of motion does not follow this form of reaction. In the more permanent form, the anatomical lesions are much more varied and extensive: the soft parts are torn and displaced, the fixed cells proliferate, and the new tissue formed thereby constitutes a true cicatrix that strongly binds together

parts whose independence of one another is essential to mobility of the joint. In place of the loose capsule in front or behind that is thrown into folds by movement in one direction and straightened out to its full extent by movement in the opposite direction, we find a short, firm band—an abnormal anterior or posterior ligament—that limits the separation of the points to which it is attached to a distance that is equal to its length. If the osteogenetic tendency is marked, or if the irritation is kept up, this new tissue or this thickened tissue may become ossified in whole or in part. The natural history of such fibrous tissue is known: after its full evolution has taken place, it may diminish in thickness and may be rendered longer and more pliable by the constant repetition of slight pressure. We see abdominal cicatrices yield and stretch under intra-abdominal pressure; we see joints stiffened by injury or disease slowly regain freedom of motion under the natural, unforced use of the limb; and although most of this stretching or mobility is probably due to the yielding of the connections of the cicatrix with the surrounding cellular tissue, yet some of it is the result of the thinning and stretching of the scar itself.

The existence of this cause of limitation, the effects of which are constantly observed after an injury or an inflammation of a joint that has compelled its prolonged immobilization, led to a widespread belief that it arose from, or was materially favored by, the immobilization; and although of late years the opinion has been vigorously, and, in my opinion, successfully, combated by surgeons of

large experience and accurate methods of thought, notably by Verneuil and Sands, it still finds expression in the quite general use of passive motion at an early stage, with the object of thereby removing or preventing the cause and its consequences.

The belief appears to have arisen partly by generalization from certain observed anatomical conditions, partly from the unquestionable fact that if a joint is kept movable it will not be stiff, and partly from the clinical observation that many joints that have been treated by passive motion have preserved or regained their functions. The opposing view is based upon the theory, supported by observation and experiment, that immobilization is not in itself a cause of ankylosis—that it is, on the contrary, the most efficient agent we possess against the inflammation which is the primary cause of most stiffness, and that passive motion is powerless to prevent ankylosis when conditions contributory thereto are present. According to this view, passive motion is either harmful or needless.

Let us briefly consider these opinions and arguments, premising that, since in any given case it is practically impossible to say that a joint that has regained its mobility under passive motion would not have done so equally well under immobilization, and that one that has stiffened under immobilization would not have equally stiffened under passive motion, our attention must be mainly given to anatomical and theoretical considerations.

The anatomical facts advanced in favor of the early use of passive motion are the outgrowths of bone that we have seen form and overlap the articu-

lar surfaces and mechanically oppose motion, and peri-articular and intra-articular bands that bind the members of a joint together and limit motion by their shortness and inextensibility. With reference to the outgrowths of bone, it is argued that if the member, the movement of which in a certain direction has been prevented by the formation of such a spur, had been previously pressed into the place thus occupied, the spur could not have formed there; or, that if it had been repeatedly pressed against the spur during its period of formation, the latter would gradually have yielded, and, under the influence of the pressure, would have become absorbed. In like manner, with reference to peri-articular and intra-articular bands, it is claimed that systematic passive motion will prevent their formation, or, if formed, will break or stretch them while they are still weak and extensible. If such a statement contained all the elements of the case, the argument and the practice would have to be accepted as sound. But it does not contain all. In respect of the formation of the spur of bone, such a spur, of course, cannot form in a place already occupied by another bone, but the loosened periosteum, by which it is so often produced, is simply pushed to a higher place by the manipulation, and there produces it. Take, for example, such a spur in the olecranon fossa: if by timely extension of the forearm the olecranon is placed in the fossa, the spur does not form there, and extension is preserved; but the spur does form immediately above the fossa, and by carrying the attachment of the posterior capsule to a higher point, and by permitting the union of

the lacerated surrounding tissues with the maximum shortening, it as effectually opposes flexion as the nodule whose formation it prevents would have opposed extension. The result in respect of immobility is the same ; the difference is only in the attitude in which the joint is henceforth fixed.

With reference to the absorption under repeated pressure of a nodule of bone that is forming or has already formed, the arguments in support of it are wholly theoretical. It is conceivable that while the nodule is still soft, before ossification has become complete, its shape can be modified by pressure, but it is also apparent that such modification can be more surely affected at that time by permanent pressure, by retaining the limb for a day or two in the position in which the pressure is made, than by frequently-repeated pressure ; this is both because the modification is maintained and because the irritation that favors the production of bone is less. Clinical experience indicates that such absorption is a very slow process, and that it is favored quite as much by the general tendency to the disappearance of superfluous bone as by pressure.

But it is against the other cause of stiffening, peri-articular thickening and bands, that the advocates of early passive motion claim it is most useful. No delay is permissible ; a week, ten days, or a fortnight at the latest, after the injury it must be begun. The limb is taken from its splints, and while the swollen and sensitive elbow is grasped with one hand to afford the necessary support and to keep the fragments from being displaced, the forearm is slowly and "gently" moved back and

forth in flexion and in extension. As the object is to stretch or break bands that are forming, the movement must necessarily be carried beyond the points where resistance begins. What is the result? We have all seen it. The patient bears the manipulation with such fortitude as he may possess, but his muscles contract involuntarily and make the range of motion less and less, and, after a few minutes, perhaps only a few seconds, of the torture, the surgeon is quite ready to accede to his prayer that it shall cease, and the limb is replaced in its splint. When the surgeon returns the next day he learns that the pain continued for several hours, and he finds the limb more swollen, the range of easy motion even less. He persists, and is finally arrested either by the refusal of the patient to permit the manipulation, or by the onset of acute inflammatory symptoms, or by recognition of the fact that notwithstanding all his efforts the range of motion is steadily diminishing. He waits a few days, perhaps, and then moves the joint freely under ether—"breaks it up," as we say; but again it stiffens, and again he sees his efforts fail, and at last, weary of the struggle, he abandons it. Thereafter, one of two results follows: either the joint remains permanently stiff, or, after the swelling and soreness have disappeared, it gradually regains its mobility under the natural use of the limb.

The same two results, permanent stiffness and more or less complete restoration of function, are also found after prolonged immobilization. The problem may, therefore, be stated as follows: After an injury a joint becomes tender, swollen, and stiff.

In certain cases, under either method of treatment, the stiffness is permanent; in others it gradually disappears. Is passive motion or immobilization during the first six weeks or two months likely to furnish the larger proportion of the latter class?[1]

The primary cause of the exudation and of the proliferation of connective tissue that are recognized as the anatomical obstacles to motion is, of course, the original traumatism; the secondary cause is the following inflammatory reaction. The severity of the injury is in each case a fixed quantity; the variable factor, the only one that is to be increased or diminished by the treatment, is the inflammatory reaction, and to this, therefore, our attention may be restricted. The question, then, may be stated in this form: How do passive motion and immobilization respectively affect the inflammatory reaction following an injury to a joint? To state the question is to answer it. Rest is universally admitted to be the best antiphlogistic measure that can be applied to an inflamed joint. Under its influence we see the swelling, heat, and tenderness subside, and we know that the amount of cicatricial tissue that has formed is only that which has come directly from the extent of the primary traumatism. The condition may be illustrated by comparison with similar conditions intentionally created by the surgeon, such as supra-condylar osteotomy or osteotomy of the internal condyle of the femur for the correction of a genu valgum. In these two operations the lesions

[1] Isolated intra-articular bands that can be broken by a single movement and have little or no tendency to reunite are rare and may here be disregarded.

of the bone and soft parts are the same in kind as in supra-condylar fracture and in fracture of the internal condyle, though perhaps less in degree; we invariably treat them by immediate and permanent immobilization, and under that treatment we find that the reaction is slight and the maintenance of function complete. Is there any adequate reason to believe that the reaction and the results after a fracture treated as promptly and in the same manner would be less satisfactory.

It only remains to inquire whether rest has compensating disadvantages to offset its advantage in restricting the amount of cicatrical tissue, and whether passive motion is free from them. An important disadvantage at once suggests itself: namely, that the torn tissues may unite with shortening, and the possibility of this must be admitted. But, will passive motion prevent it? Consider what takes place. When the joint is moved the reuniting tissues are again torn apart and a fresh trauma inflicted; the irritation is thus constantly renewed and extended, and the increasing difficulty in movement that we have clinically observed is explained by the inflammatory thickening of the untorn tissues surrounding those which have been torn. New tissue develops in this thickened untorn layer, and as it contracts in its natural evolution it more and more effectually prevents the separation of the torn tissues until ultimately they unite just as they would have united in the first place, and the only effect of the treatment is to have thickened and strengthened the cicatrical band whose formation it was designed to prevent. Both clinical observation

and theoretical considerations indicate that passive motion in this stage not only does not avoid the disadvantage arising from immobilization, but on the contrary, actually increases it. In short, it may be said that the ankylophobia of the surgeon is more dangerous to the patient than the traumatism.

Is there, then, no alternative? Must we accept a certain amount of limitation of motion as unavoidable? In the present state of our knowledge, and in certain cases, I think we must. But its extent can be measurably restricted. Systematic massage has proved to be an efficient means of hastening the absorption of the exudation and the restoration of mobility, as has also permanent elevation or suspension of the limb; and the reunion of the torn tissues with shortening may be opposed by change in the attitude of the limb made at intervals of a few days.

To avoid misunderstanding, let me repeat that in what has thus far been said about passive motion its use during the stage of reaction alone has been in mind—its use during the period in which it is followed by persistent pain and soreness. At a later period, as supplementary to the natural use of the limb, it has its value.

2. Deformity.—Of the various deformities that may result from unreduced displacement after fracture, I shall here speak of only one—that which follows the fracture of either condyle, especially the inner, and is rather widely known as the "gun-stock" deformity. It was carefully studied and described by Dr. O. H. Allis in 1880. It will be remembered that the long axis of the fully extended

forearm deviates outwardly from that of the arm, and that as the axis of motion at the elbow is at right angles to the forearm it deviates correspondingly from the transverse axis of the condyles, passing through them at a lower level on the inner than on the outer side. A displacement of the internal condyle upward or of the external condyle downward, their attachments to the radius and ulna remaining unbroken, will annul this outward deviation of the forearm and bring the latter into line with the arm or even incline it to the inner side, and, as the breadth of the condyles is not great, a comparatively slight displacement, say ¼ or even ⅛ of an inch, of the condyle may be sufficient to effect this change. This is the "gun-stock deformity;" it is hardly noticeable when the elbow is flexed, but is very obtrusive and ungraceful when the elbow is extended. In the case of fracture of the internal condyle the displacement upward of the fragment can be readily occasioned by pressure upward against the flexed elbow, the pressure being transmitted to the condyle through the olecranon; such pressure is produced when a posterior rectangular splint is used with a sling that passes under the elbow and is short enough to take the weight of the entire limb. If the limb, with a similar splint, is supported only at the wrist this undesirable pressure is not made, for the arm carries the splint, not the splint the arm. Spasmodic contraction of the flexors and extensor of the forearm may also make this pressure. In the case of fracture of the external condyle the mechanism of displacement of the frag-

ment downward is not clear; Dr. Allis thought it might be effected by the pressure of the circular turns of the bandage that secured the limb to the splint—pressing the radius, and with it the fragment, toward the posterior border of the ulna; but this seems to me to be very improbable.

The indication for treatment is clear: reduction of the displacement, if it exists, by pressure upon the fragment, or by abduction of the extended forearm until its outward deviation is equal to that of its fellow, and immobilization by dressings that will not reproduce the displacement.

Treatment.—After this examination of the principles of treatment the details need not long occupy us. The importance of immediate and complete reduction of such displacement as may exist when the case comes under observation is such that whenever a reasonable doubt exists as to the extent of the displacement or the completeness of the reduction, an anesthetic should be employed.

In *supra-condylar* fracture, in which the usual displacement is of the lower fragment backward and upward, permanent traction is usually necessary to overcome the displacing action of the flexors and extensor. This can be effected by vertical suspension of the limb, the patient being kept in bed, or by a weight suspended from the upper part of the flexed forearm while the patient is erect. The former is open to the objection that it permits an angular displacement, the lower fragment being inclined backward, and that it requires confinement to the bed; but there is no doubt in my mind of the advantages that accrue from its use in the first fort-

night after the injury; this is especially true of compound fractures, for it diminishes the reaction, permits the usual bulky dressing that is so desirable for the protection of the open wound, and at the same time secures a more thorough and persistent reduction than can usually be maintained by splints placed over such a dressing. Suspension is made by strips of adhesive plaster placed along the front and back of the forearm and attached to the support by India-rubber cords, or a weight and pulley. In simple fractures the other method may be employed from the beginning, and in compound fractures after they have become simple under suspension. An efficient procedure is to encase the limb in plaster-of-Paris from the hand to the axilla, with the elbow at a right angle, support the wrist by a sling, and suspend a weight of not more than five pounds from the flexure of the elbow. If swelling is feared, the encasement may be limited to the forearm and made continuous with anterior and posterior plaster splints along the arm.

In *inter-condyloid* fracture with marked separation, there is no practicable means surely to maintain reduction, and considerable limitation of motion is to be expected. The varying contractions of the muscles, the pressure of the enveloping fascia, increased by the swelling, and the impossibility of direct control of the fragments, combine to make the result largely a matter of chance. Experience with compound fractures in which the shiftings of the fragments could be recognized by sight and touch, has impressed me with the exceptional difficulties presented by this variety of fracture; in one

case (compound) I felt constrained to pass a long steel pin transversely through both condyles and the long projecting end of the upper fragment, for in no other way could they be kept in apposition. As even in simple cases the reaction is marked, complete encasement in plaster-of-Paris during the first week is dangerous, unless made so loose that its support is inefficient. I prefer a broad, heavy posterior plaster splint, extending from the axilla to the hand and covering about two-thirds of the circumference of the limb, the elbow being flexed at a right angle ; while hardening, it can be so moulded by pressure about the elbow that it will do much to maintain the fragments in place. Traction by a weight can be used as in supra-condylar fracture.

In fracture of *either condyle* the habitual method of treatment is by a posterior rectangular splint of metal or plaster, with the substitution in many cases of plaster encasement during the second week. The forearm is supported across the chest by a sling *at the wrist* (within, not outside, the splint), and the dressing should be worn for about a month. Immobilization in full extension of the elbow has been employed in order more surely to prevent the displacement that causes the gun-stock deformity, but the method has certain disadvantages that will probably prevent its general acceptance. There is sometimes a marked tendency to displacement forward and tilting of the fragment (internal condyle), and the swelling of the dependent hand often causes much discomfort. The latter disadvantage does not appear when the patient is kept in bed. It has seemed to me to be advisable in some cases to

employ this method for the first ten days or a fortnight and then to substitute flexion at a right angle, hoping that by that time the fragment will have contracted adhesions that will prevent its easy displacement upward.

With fracture of either condyle is sometimes associated dislocation of the bones of the forearm and the fragment from the humerus; this complication is more frequent with fracture of the internal condyle, the dislocation being backward and upward, and the head of the radius resting behind the external condyle. Under such circumstances retention may present special difficulties; they appear to be best met by immobilization, with the elbow flexed well within a right angle.

If the case is one to which the necessary time can be given, daily massage of the limb may be advantageously employed to hasten convalescence. It should be made very gently at first, and the pressure gradually increased. The sittings may occupy ten or fifteen minutes, and the rubbing should be from below upward. Care must be taken to avoid giving pain, either by too great pressure or by movement of the joint.

For the reasons already given it may in some cases be advisable to change the angle of flexion from time to time; and in any case in which absolute fixation or great limitation of motion is expected, that attitude should be given to the joint in which, if stiff, the usefulness of the limb will be greatest.

After-treatment.—The length of time for which the splint must be worn is greatest—about six weeks—for the supra-condylar and inter-condyloid fractures,

and about four weeks for those of either condyle. After removal of the splint the limb should, for a few days, be supported in a sling, and exercised in slight movements. If the increase of the range of motion under natural use should be slow, it may be hastened by passive motion or by special exercises, as by carrying a weight to increase extension and by India-rubber traction from the wrist to the shoulder to increase flexion.

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