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THE HODGEN SUSPENSION-SPLINT.

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THE chief reliance of physicians in the treatment of fractures of the femur appears to be upon Buck's extension, but with this method the necessary movements of the patient, the irregularities of the bed, with consequent difficulty in adjusting the padding, or the carelessness of the surgeon, not infrequently result in over-lapping or in "angling," with a resulting crooked and shortened bone. The after-care of a case treated in a properly adjusted Hodgen splint is so trifling, compared with that required by Buck's method, that I am tempted again to present the claims of the suspension-splint of Dr. John T. Hodgen. Surgeons use with Buck's extension from twelve to twenty pounds pull, and shortened legs attest its inefficiency. The comparatively perfect result to be obtained by the judicious use of a Hodgen suspension-splint is not, I believe, to be attained with any other method, and the amount of the extending pull need not exceed ten pounds.

Extension is so universally admitted to be of prime importance in the treatment of the fractured femur that I shall not here endeavor to prove its value, nor do I deem this the place to compare and discuss the relative merits of the various procedures resorted to in the effort to secure equable and continuous extension. Many and various are the methods devised. A description of Hodgen's suspension-splint is found in many of the text-books. Few authors, however, seem to appreciate fully the benefits to be derived from suspension and extension as combined in this splint; yet its use is certainly becoming widely extended, though rather by example than by force of authority. It is a splint which will win its way into favor by its own virtues after it is once understood by surgeons of mechanical tact. I hope, since the splint is simple in its construction and theory, to make its application and principles so plain that every surgeon can use it with comfort and advantage to his patient.

Simple and effective continuous extension was, I think, first obtained in oblique suspension by Nathan R. Smith, when he introduced his anterior splint, of which the Hodgen suspension-splint is a modification. The advantages of the Hodgen splint are:

1. Easy adjustment.
2. It leaves the thigh exposed to inspection.
3. The muslin supports on which the leg and thigh rest can be separately adjusted, so that the tension on any one of them can be easily changed.

This splint in the hands of an expert secures nearly perfect immobilization, with extension so equable and effective as to give practically perfect results; and the freedom of motion allowed the patient does not interfere with the union of the broken bone—the splint and leg move with the body of the patient. The only motion is at the hip-joint, and there is no possibility of angling at the fractured point by the dragging of the leg on the bed as the patient moves from one side to the other. The patient can sit upright in bed or use the bed-pan without disturbing the fracture.

Description.—The splint itself, as originally devised, is composed of a single piece of No. 2 wire, bent as shown in Fig. 1. The sliding hooks D D′ and E E′ are used for attaching the suspending cords to the splint. The use of the arch O is to maintain the proper width of the splint at its upper end, viz., 8 or 10 inches. This arch is loose and is easily slipped into position over the ends of the wire which form the splint before the latter is applied to the leg. The width of the splint at the foot is about 5 inches, and is determined by the bend in the wire which forms the body of the splint. The wire hooks E E′ and D D′ present at one end a free loop for the attachment of the supporting cords, while the other end is coiled somewhat snugly around the lateral bars of the splint at D and E. The lateral bars extend upward on each side of the leg, so that the two ends of the wire reach, the one to a point *above the pubes*, and the other, on the outside, *nearly to the crest of the ilium.* The bend of the splint at the knee permits slight flexion of the leg.

The distance from the foot of the splint to the bend in the knee is 22 inches. From the bend at the knee to the upper end of the splint is 20 inches. The suspending apparatus is composed of, first, the pulley A, which is fixed in a high framework extending 8 feet above the bed, or preferably, in the ceiling; secondly, of the perforated sliding block B and the cord B A C; thirdly, of the two cords D C E and D′ C E′, of equal length with a loop at each end for attachment to the wire hooks at D D′ and E E′. These cords are passed through

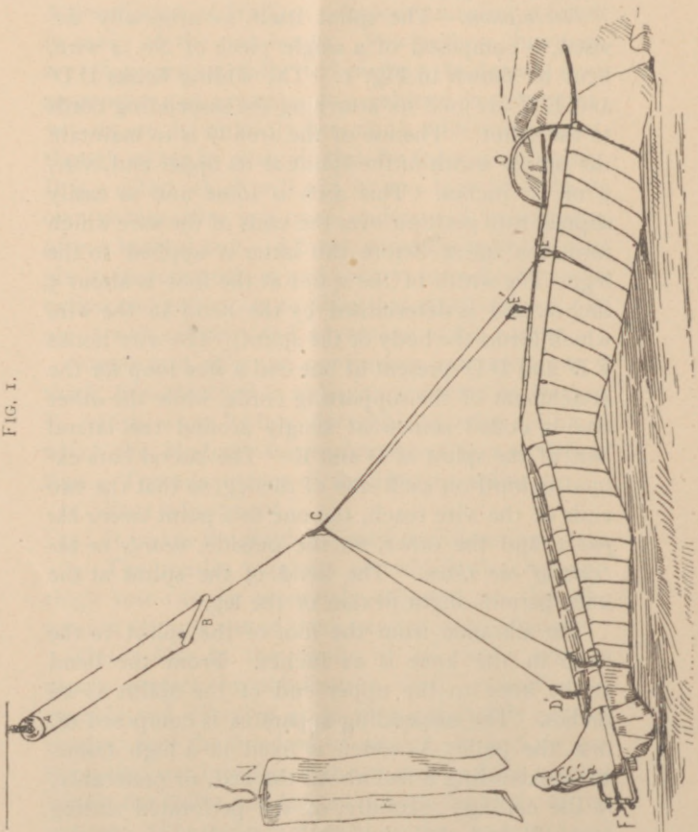

FIG. 1.

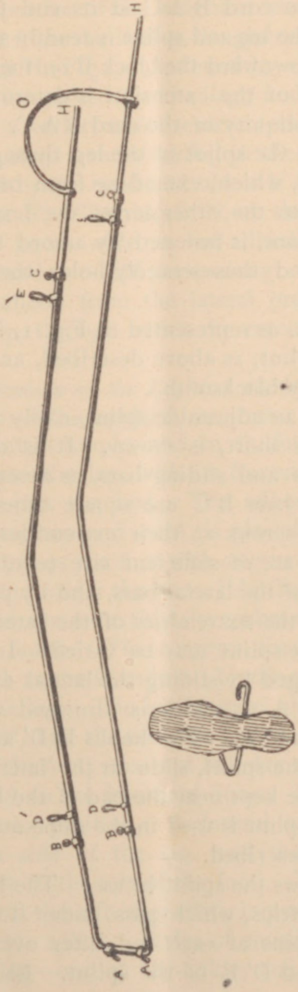

FIG. 2.

a loop in the cord B A C at its end C. The suspension of the leg and splint is readily accomplished by sliding downward the block B on the cord B A C. The amount of the extension is determined by the degree of obliquity of the cord B A C. It is transmitted from the splint to the leg through the adhesive strip H, which, extending from one tuberosity of the tibia to the other across the board N at the sole of the foot, is fastened by a cord to the cross-bar at F, and thus securely holds the leg in the splint.

The splint, as represented in Fig. 1, is the simple solid-wire splint, as above described, and is readily made by any blacksmith.

In Fig. 2 an adjustable splint, easily fitted to any leg, long or short, is shown. It is composed of hollow tubes and sliding-bars, as described below. The lateral bars B C are square tubes, furnished with thumb-screws at their extremities, B and C. These tubes are of sufficient size to admit the terminal ends of the lateral bars, and by pushing in or pulling out the extremities of the lateral arms the length of the splint may be varied. Its width can also be changed by sliding the lateral arms into the hollow tube A A, which is furnished with thumb-screws at A and A. The hooks D D′ and E E′, for suspending the splint, slide on the lateral bars B C, but should be kept near the end of the hollow tubes B C. The splint is used in the same manner as the one before described.

Fig. 1 shows the splint in use. The leg is resting on muslin strips, which pass under it. These are secured by pins at each end, after overlapping the arms D E and D′ E′ of the splint. Each strip supports its proportion of the weight of the leg. These strips extend from the heel to the gluteal fold. The adhesive strip H (Fig. 1), softened by warmth or by turpentine, is applied to the leg, and secured in position by a roller, which extends as high as the knee. This strip secures the leg in the splint, since it is fastened by the cord and block N to the foot of the splint at F. The block N, at the sole of the foot, should be as wide as the adhesive strip, and about three and one-half inches long. It then protects the malleoli from the lateral pressure of the adhesive strip, through which the extending force is applied.

The Suspension of the Leg and the Adjustment of the Fracture.—The application of the Hodgen suspension-splint is simple, and in skilful hands painless. Suppose the leg, with its fractured femur, to be resting upon the bed. The adhesive strip H, with its foot-piece and cord, is placed in position, an assistant grasps the foot with one hand, and, with the other hand under the knee, lifts the leg from the bed, while at the same time he makes steady extension of the femur. The surgeon then applies the roller as high as the knee-joint, binding the adhesive plaster to the leg. The leg is again allowed to rest upon the bed, but the assistant maintains moderate traction on the foot, so as not to relax the extending force applied to the fractured bone. The splint is then put into position. A lateral arm is placed upon either side of the leg, and the cross-bar is brought close to the sole of the foot. The cord and block N, with the adhesive strip, is now fastened to the foot of the splint. Strips of muslin are passed under the leg—one at the ankle, one at the knee, and perhaps two under the thigh. These are secured by pins to the lateral arms of the splint, while it is held so that the inner arm extends above the pubes, and its outer arm, reaching nearly to the crest of the ilium, has its upper extremity not far from the anterior-superior spine of the ilium. The lower end of the splint is on a level with the malleoli. The inner wire arm may need to be shortened or bent upward, so as to give the patient opportunity to sit upright, but it should always extend well above the pubic bone. The leg can now be suspended by attaching the cords D C E and D′ C E′, and adjusting the slide B so as to lift the splint and leg from the bed. The cradle of cloth strips upon which the leg is to rest is now made complete by adding strips of muslin, and adjusting them to the outline of the leg, as indicated in the cut. No special or violent attempt at the adjustment of the fractured bone is made, except where there is marked lateral displacement, as in some transverse fractures. The free swing of the leg, and the efficiency of the extending force, secure a perfect adjustment in a few hours. The fracture "sets" itself.

The flexion of the leg on the thigh should not be very sharp, for if the bend approaches a right angle the elevation of the knee is necessarily great and most of the extending force applied to the thigh would be through the muslin strips on which the upper part of the leg rests (those just at and below the bend of the knee). The angle of flexion at the knee may be varied from that of the splint by lengthening or shortening the strips which support the thigh. The foot may be elevated or lowered and the support rendered by the muslin strips under the thigh varied, by sliding the loop at C downward toward the foot or upward toward the groin.

The flexion of the knee is only sufficient to put the leg in a comfortable position, relaxing slightly the tension of the hamstring and gastrocnemius muscles. The slight flexion of the thigh on the pelvis puts at rest the psoas and iliacus, and the rectus extensor of the thigh. The muscles are placed in a state of equilibrium.

External rotation, if it occurs, can be obviated by securing the foot to a foot-piece, or by a muslin strip passed around the outer border of the ball of the foot and fastened to the inner arm of the splint.

The degree of extension necessary to accomplish the result desired may be determined in part by the sensations of the patient. The position of comfort is often the position of safety, as extension is required only to overcome the tonic contraction of the muscles. The counter-extending force is the weight of the body. Much less extension is required in splints that suspend the leg and remove the resistance of friction of the leg on the bed than is required when the leg rests upon the bed, and weight and friction are first to be overcome. It is never necessary, when using this splint in an adult, to apply (as recommended by Hamilton when speaking of other methods of making extension) twenty pounds as an extending weight; or, as he states in his work on *Fractures and Dislocations*, published in 1880, "one pound for a child one year of age, two pounds for a child two years of age, and so on, adding one pound for each year up to the twentieth." An extension of twenty pounds, applied through an adhesive strip to the leg, and pulling upon the knee-joint and femur, is a serious trial to the patient's endurance, and it taxes the surgeon's ingenuity to maintain steadily such a force.

The amount of extension required in this suspension-splint is much less, being only from three to ten pounds, for there is no friction to overcome, and so long as the patient remains in bed there is no appreciable variation in the extending force provided the point of support is eight or ten feet above the plane of the bed. It is a quiet, persistent, non-irritating and effective pull. There is no perineal band to fret and worry the patient. The extending force is determined by two factors, and these are entirely within the control of the surgeon, viz., the obliquity of the extending cord and the weight suspended. The first can be varied by the relative position of the bed and the suspending pulley, and the latter can be increased, if desired, by placing sand-bags across the lateral bars of the splint.

It seems difficult for some persons to understand how extension can be applied to a fractured thigh by a direct traction upon the leg, without counter-extension through the perineal band. They fail to recognize the efficiency of the weight of the leg as an extending force and the stability of the body as a counter-extending force. The amount of the extending force that is transmitted through the adhesive strip in the suspension-splint, may be measured by substituting a spring balance for the cord, which in the cut connects the block N with the foot of the splint. A small portion of the extending force is, however, transmitted through the strips which support the limb in its cradle, and those who wish can, by mathematical formulæ, compute the absolute amount of the extending force obtained by oblique suspension.

Professor Francis E. Nipher, of the Washington University, and Dr. A. K. Worthington, now of Denver, used the following formulæ for determining the extending force. The line D in the diagram (Fig. 3) represents, approximately, the line of the splint and the femur.

The pull on the cords C E and C E′ and also on C D and C D′ (Fig. 3), can be accurately measured. The angles a and b (see Diagram, Fig. 3) can also be measured. The traction force along C E and C E′ is represented by A, and that along C D and C D′ (Fig. 3) by B. The forces A and B being known as also the angles a and b, we can readily calculate the horizontal components F and F′.

The resultant of F and F′ will represent the direct traction force exerted along the line D, or the amount of efficient extension applied in the line of the femur.

In a particular case where the patient weighed 150 pounds, and the suspending cord, C (or in Fig. 3, A B C) formed an angle of 15° with the perpendicular:

It was found that the pull	A = 11.5 pounds.
And the pull	B = 10.5 "
The angle	a = 40°
The angle	b = 75°.
Hence by trigonometry	F = A cos. a.
And	F′ = B cos. b.
Whence by substitution	F = 11.5 x cos. 40 = 8.8 pounds.
" " "	F′ = 10.5 x cos. 75 = 2 7 "
Therefore the resultant of	F and F′ 6 1 pounds.

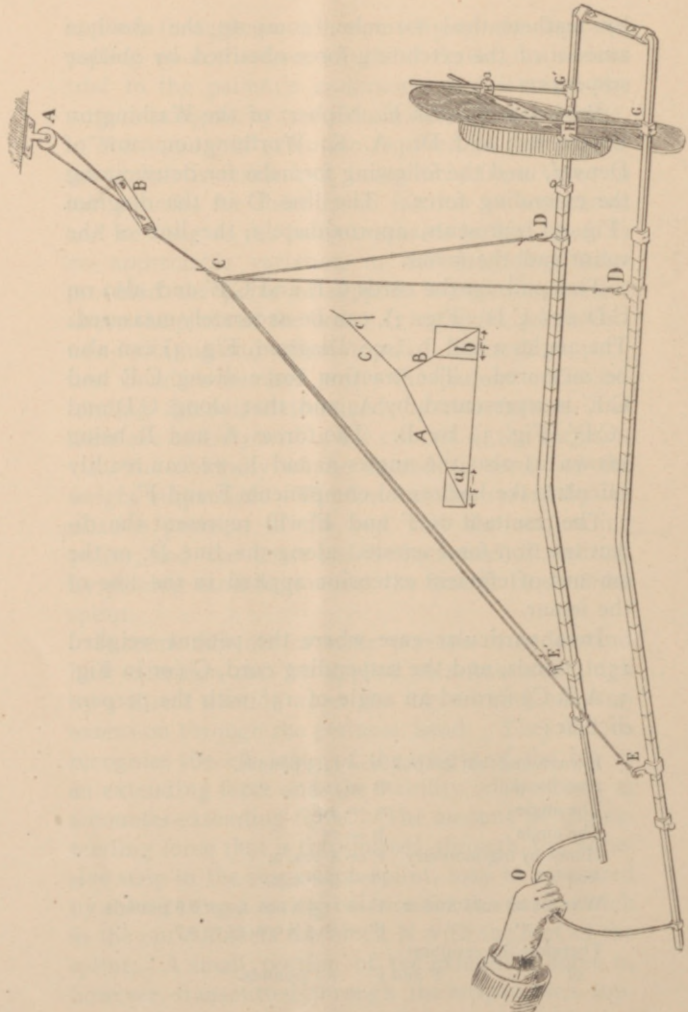

FIG. 3.

F and F′ act in different, opposing directions, hence their resultant is the difference between them, or 6.1 pounds, which represents the amount of the extending force applied to the femur in this case. If the angle C was increased to 36°, it was found :

That the angle a = 35°
" " " b = 105°.

Here the forces F and F′ are exerted in the same direction, since the angle b is greater than a right angle, and their resultant is the sum of the forces, which (by the same formula as before) is found to be 14.7 pounds. The weight of the leg was estimated at 21 pounds.

The loop C in the cord B A C (Fig. 3) is loose and can be slipped along the cords D C E and D′ C E′ so that the angle made by these cords with the splint can be changed with the obliquity of the suspending cord B A C. The lower leg should be parallel with the bed, while the heel is not more than two or three inches above the bed.

If the pulley through which the cord passes is fixed in a ceiling which is 9 to 12 feet high, a perpendicular line dropped from the pulley should fall beyond the foot of the adult patient. In the case of a child, where the weight of the leg is less, the obliquity of the cord should be greater. The obliquity of the cord should be sufficient to make an angle of from 15° to 35° with the perpendicular. If there is any tendency for the patient to slide toward the foot of the bed, it may be obviated by raising the foot of the bed by means of blocks. In the case of a child, it may be well to pass a cord loosely about the body under the arms, and fasten it to the head of the bed, to serve as a check to any great change in the position of the patient. The leg is open for inspection and the supporting strips can be readjusted as the parts atrophy. The slight natural anterior curve of the femur can be maintained. The circulation is undisturbed, for the nutrition is not interfered with by the pressure of retentive apparatus and it is as perfect as it can be during enforced quiet. The leg can be kept cool or warm as desired. The patient may sit up or lie down as comfort suggests. The bed-pan can be used without disturbing the fracture, and the best possible result in fracture of the shaft can generally be obtained, viz., no appreciable shortening and early union. This is obtained without bed-sores or any of the constitutional complications which are liable to follow confinement in a fixed position. The splint is well adapted to the treatment of all fractures of the femur, whether they are intra- or extra-capsular, through the trochanters, the shaft, or the condyles. The results of the treatment of fractures of the neck of the thigh in the splint are very satisfactory in the great majority of cases. Most of the unsatisfactory results obtained are probably due to imperfect adjustment of the fractured ends. The feeble aged persons who are most liable to this injury, derive comfort from its use and greater freedom of motion than they can enjoy with any other apparatus, or than pain will permit if allowed to go without treatment or a splint.

After a long experience with the splint in private practice and hospital work, and after having observed its employment by the late Dr. John T. Hodgen during the last fifteen years of his life, I know of but one practical difficulty which arises in its universal and immediate use in all fractures of the femur. This objection pertains only occasionally to the fractures of the middle third of the bone in children. These exceptions are rare, and if a perfect adjustment of the extending force to the necessity of the individual case could be obtained at once, they would be reduced to a minimum. The objection is found in the spasmodic contraction of the muscles, which at times is so frequent and violent, immediately after injury, that some lateral pressure is necessary for the comfort of the patient. This spasm may in part be controlled by lateral supports to the thigh or by permitting the leg to rest upon the bed for a few days with extension applied after Buck's method. No form of dressing will uniformly control it. After this irritability subsides, the leg is more comfortable and more efficiently treated in the suspension-splint. This clonic contraction of the muscles is more likely to be present if the extending force is in excess of the necessities of the case. The excessive tension acts as an irritant.

The only obvious change effected by the motion resulting from the spasm is an increase in the amount of the provisional callus. It does not delay union, but provokes by irritation an increased inflammatory deposit about the break. I find that a sand-bag partly full placed on the thigh while it is in the suspension-splint materially mitigates this spasmodic action. Fortunately, these cases are rare. Clonic contraction will, in isolated cases, occur with any splint and under any plan of treatment, for no lateral support or compression can prevent the contraction which accompanies a muscular spasm. Opiates are some-times useful, in the case of nervous children, for a few days after such an injury is received. The plaster-of-Paris dressing is not, I think, admissible except in children less than eighteen months old.

This splint, and this manner of applying extension, afford a most perfect means of neutralizing the tonic contraction of the muscles which so often determines shortening. The oblique suspension gives continuous and equable extension of an amount sufficient to accomplish a perfect result, without the waste of any force, and it insures to the patient the most perfect liberty attainable by any known means compatible with comfort and safety.

The point of support, the pulley A, Figs. 1 and 3, should never be brought nearer the plane of the bed than eight feet. This gives the patient the full liberty of the bed without changing materially the extending force.

The foot-piece shown in Fig. 3 is one which I have used with some satisfaction in fractures of the neck of the femur. It is also useful where the splint is used in the treatment of compound fractures of the leg. It will prevent rotation, it obviates drooping or extension of the foot, and is easily adjusted.

Dr. J. Freund, of Champion, Michigan, has devised a foot-piece which answers a good purpose. It is held in position by two transverse slips of wood fastened by thumb-screws to the lateral wires of the splint. The inclination of the foot-piece is fixed by a third thumb screw, which controls the inclination of the foot. It can be used with either splint and is an effective foot-piece.