On the treatment of cicatricial contraction of the fingers by transplantation of completely separated skin flaps / by Robert Kennedy, M.A., D.Sc., M.D., Dispensary Surgeon to the Western Infirmary, Glasgow.

Reprinted from Glasgow Hospital Reports, 1899.

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The ultimate effect of the destruction of a sufficiently extensive area of the cutis vera on the flexor aspect of a joint is well known. The replacement of the normal tissue by a cicatrix gives rise, as the latter contracts, to a permanent flexion. In no part of the body is this result better marked than in the case of the fingers. Destruction of the entire thickness of the skin on the flexor surface of a finger, brought about by say a burn of the fourth or higher degree, if left to heal by the natural process, is certainly followed by a very marked flexion of the finger. This contraction, if the damage involves the greater part of the flexor surface of the finger, and perhaps a small part of the surface of the palm, will become so extreme that the finger will be brought into contact with the palm, and fixed there by dense cicatricial tissue.

A condition such as this is one which involves much interference with the normal use of the hand, and becomes a very serious matter in the case of those who require or will require to earn their livelihood by manual labour. The removal of a deformity of this kind is, therefore, a matter of very considerable importance to the patient.

Fixation of the fingers in the extended position while healing is in progress, if indeed always possible, can scarcely

be said to be effective in preventing the formation of the deformity, as the contraction which ultimately takes place in the scar, after removal of the splint, will flex the finger as much as if the precaution had not been taken. The object of this paper is, however, to consider what line of treatment should be adopted in cases in which the cicatricial contraction is already present, and in which the wound is entirely healed.

The method of treatment by simple section of the cicatrix and forcible extension of the finger will be followed by recurrence of the contraction, and this recurrence will not be prevented as an ultimate result, although the finger is kept extended, until the wound is covered with epithelium, and although the process is hastened by small grafts of epithelium. The only result which can be expected from this treatment is that on liberation of the finger from the extending force, it will gradually return to its condition of extreme flexion

To prevent the recurrence of the condition, an operation of a more radical nature is required, one which will replace the cicatricial area by a tissue which will not contract. The plastic operation of separating up the cicatrix, and mobilizing flaps of sound skin in the neighbourhood to the extent required to allow of extension of the part, might be applied in the case of the fingers. In this case the flap of sound skin would require to be taken from the palm, as in Busch's operation for contraction of the palmar fascia; but the amount of separation which would be required before the finger could be extended, would be so great that it would simply be a case of grafting with the graft taken from the palm.

The method which has been employed in the cases here recorded, is that of transplantation of tissue from a distant part to replace the cicatrix, previously completely dissected off. The older method of grafting of small portions of epithelium was not tried, as this does not prevent subsequent contraction. A single strip of epithelium sufficiently large to cover entirely the raw surface left after removal of the

cicatrix (Thiersch's grafting) was tried, but, as the report will show, with unfavourable result, although the graft healed in perfectly. The method which did give good results was that of transplantation of the entire thickness of the skin, a method employed by Wolfe of Glasgow in 1875 for the removal of ectropion, and recently advocated by Krause of Altona, who, by improving the technique, has done much to ensure the success of this operation.

CASE 1.

Contraction of little finger, due to cicatrix of burn. Excision of cicatrix and transplantation of skin. Failure.

A. M., female, aged 1½ years, was brought to the Victoria Infirmary Dispensary on 28th November, 1893. The little finger of the right hand was bound down to the palm by a dense cicatrix, the result of a burn received some months previously. Under chloroform the cicatrix was divided transversely at several points, and the finger forcibly extended. This was accomplished without dividing the tendons, but the sheath of the tendons was in great part exposed, the divided cicatricial tissue not being more than sufficient to form one or two bands stretching across the sheath. The entire cicatricial area was then excised, leaving a wound surrounded by healthy skin, and having for its floor nothing but the sheath of the tendons, and extending throughout the entire flexor surface of the finger, and projecting also for a short distance into the palm. A lenticular area of skin of sufficient size to cover the wound completely was excised from the forearm, being dissected off free from adipose tissue, and transferred to the wound on the finger, where it was fixed in place by a few sutures of horse hair. The finger was then covered with a piece of perforated green protective silk and dressed. After the wound in the forearm had been sutured, a forearm splint was applied. This operation was performed in the out-patient department, and the child was brought back twice weekly for inspection.

At the end of ten days the dressings were removed to ascertain the result, and it was found that the transplanted piece of tissue was living and looking red and healthy, although the superficial corneous layer of the skin was soft and separating. Dressings and splint were reapplied. When the child was next seen at the end of the fourteenth day, it was found that the dressings had been removed and reapplied by the mother, in order to show the interesting result to the child's father. On inspection of the result, the grafted piece of skin was found separated and lying in a collection of pus, while the surface of the finger was covered with granulations. The child was seen some months later, when the original condition of contraction had been completely reproduced.

CASE 2.

Contraction of index, middle, and ring fingers due to cicatrix of burn. Excision of cicatrix and transplantation of skin. Success.

D. M., male, aged 2 years, was admitted to Dr. Patterson's wards in the Western Infirmary on 2nd November, 1897. When patient was six months old he sustained a burn on the flexor surfaces of the second, third, and fourth digits, and over part of the palm of the right hand. The burn was caused by the child grasping a red hot cinder. When the burn was healing the three fingers were being gradually drawn towards the palm, and by the time that cicatrization was complete, the fingers had been drawn almost completely into the palm. When the patient was first seen, a year and a half after the accident, the following was the condition found:

The right hand presented the index, middle, and ring fingers flexed to the extent of being in close contact with the palm. They were held in this position by tense indurated bands of cicatricial tissue, which were so rigid as to prevent any appreciable extension, even on considerable force being used. The cicatricial bands, fused in the palm, extended from the lower third of the palm to the terminal phalanges of the

fingers. The fingers also presented a degree of webbing throughout the extent of their first internodes.

On 5th November, 1897, under chloroform, and after rendering the limb bloodless, the cicatrices were divided transversely at several points, and the three fingers forcibly extended. This was effected without division of the flexor tendons, and the incisions in the cicatrices were torn open to the depth of the tendon sheaths. Next, the entire cicatricial area on the three fingers and palm was dissected off, the result being that on the flexor surface of each finger there was a wound left, bordered by healthy skin and having for floor the sheath of the tendons, while the wound in the palm had for floor adipose tissue. Next, the tourniquet was removed, and bleeding arrested by torsion, and the capillary bleeding by pressure. While this was being done, the skin flaps were cut from the forearm. Two lenticular flaps of sufficient size, each to cover a finger and portion of the palm, were cut, taking the entire thickness of the skin, and dissecting the flap from the underlying adipose tissue. These two flaps were transferred to the index and ring fingers, being laid on the tendon sheaths, and fixed by several points of horse hair suture to the healthy skin around. The entire extent of the wounds on these two fingers and corresponding parts of the palm was thus covered over. In order to cover the middle finger, and for the sake of comparison of the value of the two methods of grafting, a Thiersch's graft was cut of the requisite size from the forearm, and laid over the wound on the finger and corresponding part of the palm. When the operation was completed, the entire wound on the three fingers and palm was covered over. The grafts were then covered with perforated green protective silk and dressings applied. The two areas on the forearm from which the whole skin grafts had been cut, were now closed completely by silk-worm gut sutures. The edges of the skin came easily together, after the skin on either side had been dissected up for a short distance. The limb was then fixed on a forearm splint.

The first change of dressings was made at the end of fourteen days. All the grafts were found to have taken. Minute

portions at the two extreme ends of the skin grafts were dead and separating, but with this exception the grafts were in a healthy condition, presenting a red colour and adhering firmly to the fingers. The redness of the surface was due to the separation of the superficial layers of the epidermis, which lay in the dressings as a soft debris.

The dressings and splint were applied for another fortnight, and, when removed at the end of that time, the grafts were found firmly healed in, the surface of the whole skin grafts presenting a normal skin surface of a redder tint, however, than is natural.

As a precaution the hand was covered up for another fortnight, at the end of which time the child was allowed to use the hand.

The patient was seen on 6th January, 1898, two months after the operation, and it was then found that while the index and ring fingers remained perfectly straight, the middle finger, which had been covered with the Thiersch's graft, was tending to contraction. The graft on the index finger was perfectly outlined by a cicatricial line, and presented the appearances of normal skin, and had acquired the transverse lines at the joints.

This patient was again admitted to hospital on 28th June, 1898. The condition of the hand then, about seven months after the operation, was as follows (Fig. 1): The contraction of the middle finger (Thiersch's graft) had recurred completely, the finger being bound down firmly into the palm. The index finger remained straight, while the ring finger was semiflexed, being drawn down chiefly by adhesions to the middle finger.

On 7th July, 1898, the cicatricial tissue was removed from the flexor surface of the middle finger, and also the portion of cicatrix which involved the ring finger. Whole skin grafts were cut from the thigh and stitched into the gaps on the fingers and palm. The fingers were then dressed with gauze, green silk protective being avoided. The limb was then fixed on a splint.

The dressings were not disturbed till the end of five weeks, when it was found on inspection that both grafts had taken

perfectly. The skin had a normal appearance, and the fingers were perfectly straight, and the patient was allowed to use the hand.

This patient was again examined on 26th August, 1899, *i.e.*, about twenty-two months after the first, and fourteen months after the second operation. The result had proved entirely successful (Figs. 2 and 3). All three fingers could be voluntarily extended to almost their normal degree, and flexed also fully into the palm. The use of the hand was thus entirely regained, and very little contraction had occurred in the transplanted flaps. The flaps had a somewhat scaly, and at the margins a somewhat cicatricial aspect, but otherwise appeared to fulfil the requirements of the flexor surface of the fingers. Sensation over the entire transplanted part was apparently normal, as tested by pricking with a needle. On the surface of the grafts minute hairs were visible by the aid of a lens. The grasp of the hand was as good as that of the other hand, and the child made constant use of the hand in a perfectly normal manner.

CASE 3.

Contraction of ring and little fingers from cicatrix of burn. Excision of cicatrix and transplantation of skin. Success.

D. C., male, aged 12 years, was admitted to Dr. Patterson's wards in the Western Infirmary on 3rd June, 1898.

When patient was one year old he met with an accident to his right arm, for which the arm was fixed in a sling, which was pinned round the hand to prevent movement. While the arm was thus fixed, he set fire to a box of matches which fell inside the sling, and inflicted a severe burn on the ring and little fingers. The burn was treated without any particular precautions to prevent contraction, and when the dressings were removed it was found that both fingers were fully flexed by cicatricial adhesions into the palm.

His condition on admission to hospital was the following: The little finger was fixed by dense cicatricial adhesions closely

to the palm. These adhesions extended from the palm to the tip of the finger, the entire length of the finger being practically fused with the palm. The finger was also markedly shortened, and had undergone a movement of rotation, due to the contraction of cicatricial tissue on the inside of the finger and palm, to the extent that the nail presented on the inner aspect. The ring finger was also firmly bound down to the palm by cicatricial adhesions, extending from the palm along the finger to its terminal phalanx.

On 9th June, 1898, the cicatrices were divided and attempts made to extend the fingers. This, however, could not be effected on account of contraction of the tendons. The tendons were therefore lengthened at one of the nodes where the sheath is deficient, and the tendons therefore easily accessible. This was done by a method which allows of lengthening without severance of continuity. When the fingers by this means had been brought to the fully extended position, an attempt was made to remedy the rotatory displacement of the little finger, but this was found to be impossible. The entire cicatricial area was then excised, and when this was completed the tendon sheaths in the fingers were quite denuded, the entire breadth of the flexor surface having been removed. Two grafts of the whole thickness of the skin, and of the requisite size completely to cover over the defect, were cut from the front of the thigh and implanted on the fingers, being fixed in place by horse hair sutures. The grafts were covered with perforated green silk protective and dressed, and the forearm and hand fixed on a splint.

At the end of seventeen days the dressings were removed for the first time, and it was found that both grafts had taken throughout their whole extent, with the exception of two minute portions at the ends of the ring-finger graft. The stitches were removed. The superficial corneous layer was soft and separating, but beneath that the graft showed a normal skin surface. The dressings were reapplied, omitting the green silk protective, and the patient was dismissed from hospital, to return as an out-patient.

Ten days later the part was dressed for the second time.

Both grafts were found healing well, and presented corrugated surfaces which were dry and of the colour of normal skin. There was a small raw surface at the proximal end of the ring-finger graft.

The case was again seen at the end of July, seven weeks after the operation, when the fingers were found straight and the grafts presenting the characters of normal skin, and looking so well that the boy was allowed to use the hand.

This patient was examined again in July, 1899, thirteen months after the operation. The condition then was as follows (Figs. 4 and 5): Contraction had not recurred at all in the ring finger, and very slightly, if at all, in the little finger. The ring finger could be voluntarily completely extended and flexed into contact with the palm, but it could not make firm pressure on the palm. The little finger could be voluntarily extended and flexed, but there still of course remained the rotatory displacement, which was not remedied at the operation, and it still remained somewhat shortened. The use of his hand had been gradually improving during the year, and he used both fingers in grasping, and could grasp a body $\frac{3}{4}$ inch in diameter firmly with them. The grafts showed the transverse markings at the flexures, which had been assumed by the grafted skin. The cicatricial lines round the margins of the grafts were evident. The surfaces of the grafts were of the same colour as the flexor surfaces of the other fingers, but here and there showed a somewhat scaly appearance. Sensation of touch and pain was normal throughout the extent of the grafted portions, and the grafts were movable, as normal flexor skin surfaces, on the tendon sheaths below, but grasped from side to side they felt somewhat denser.

The first point which may be considered in connection with the above cases is the comparative value of Thiersch's grafts of epidermis, and of transplantation of the entire thickness of the skin. The former method was employed only in the case of a single finger, and of course there is an objection to arguing from a single case. However, in that case the

conditions were entirely favourable as a test of the value of Thiersch's grafts; for the grafted epidermis healed in perfectly without reaction of any kind. Despite this favourable progress, the finger grafted by this method showed at the end of two months a distinct tendency to reproduction of the contraction, while the two neighbouring fingers remained perfectly free from contraction. This reproduction of the contraction continued progressively, until when seen at the end of seven months the contraction of the finger was as extreme as before the operation, while no contraction had yet occurred in the two neighbouring whole skin grafts, although the ring finger appeared semiflexed from adhesions to the middle finger (Fig. 1). On general considerations also this result of Thiersch's grafting is not surprising. The graft represents merely a covering of epithelium, and the important structures present in the cutis vera have nothing to represent them. The structure therefore of the new flexor surface cannot be other than that of cicatricial tissue, and, therefore, must be expected to undergo much contraction.

With regard to the transplantation of the entire skin, the cases show that if the immediate result of this operation is successful, the ultimate result is also good. The new flexor surface does not tend to undergo contraction to any appreciable degree, and approaches in characters as nearly as could be expected to the normal tissue. The grafts appear and feel like normal skin, and soon take on the normal markings at the flexures of the joints. Sensation also is developed in them, apparently as perfectly as if they were the natural covering of the part. With the exception of the first case, all the skin grafts healed in without trouble, although the surface on which they were implanted, viz., the naked tendon sheath, did not look like one best fitted for the nourishment of portions of tissue so thick.

In carrying out these operations, the use of antiseptics was limited to the thorough sterilization of the skin before operation. The application of antiseptics to the wounds ought to be avoided, as the vitality of the tissues may thus be lowered below that which is necessary for success of the grafts. The

entire cicatricial area is removed, and, if the tendons have undergone contraction from the long duration of the flexed position, these must also be divided or lengthened before anything further can be done. In the case in which this was necessary, eleven years had elapsed from the date of accident, while in the other two cases, in which respectively one year and eighteen months only had elapsed, the tendons did not resist extension after removal of the cicatrix.

Haemorrhage ought to be arrested before applying the grafts, and if the scar is dissected off while the hand is bloodless, the tourniquet ought to be removed immediately this is effected, in order to give time for the arrest of haemorrhage while the graft is being cut. In preparing these grafts, I have never removed the adipose tissue with them, but have always outlined the lenticular area to the depth of the adipose tissue, and then dissected the skin off. There has never been any difficulty in closing the wound left after removing the graft, although the adipose tissue was left, all that was found necessary being to mobilize the skin for a short distance in the vicinity. The graft should be of the requisite size exactly to fill the gap presenting on the finger, so as to leave no surface to heal by granulation, and also not to overlap the surrounding skin at any point. These grafts are usually simply laid on the part to be grafted, but in the case of the fingers, it will not be found easy to keep them in place without suturing. The smooth tendon sheath affords no hold for the graft, and the edges also of a strip of skin so narrow cannot well otherwise be prevented from rolling inwards. The application of a few horse hair sutures kept the grafts in perfect position, and did not prevent even the portion of the graft transfixed from retaining its vitality and healing.

The green silk protective, employed in all except the second operation in Case 2, was used to prevent the dressings from adhering to the grafts and displacing them when being removed. I think, however, that this method of dressing is unfavourable to the grafts. Although perforated, the impervious tissue kept the part always moist, a condition favourable for sepsis, and also doubtless accounting for the separation

of the corneous layer of the epidermis. This separation and breaking up of the corneous layer of the epidermis is a danger, as micro-organisms imprisoned in the superficial layers, which might have resisted the sterilization of the skin, are thereby rendered effective. In the case in which the protective silk was not used, and the part dressed simply with gauze, the corneous layer of the epidermis did not break up and separate. Of course, if a dry dressing is employed, it ought to be left on until it is certain that the grafts have firmly healed in, as any attempt to remove it will be almost sure to tear the delicate early adhesions of the graft. In the case in which it was tried, the grafts were so firmly fixed at the end of five weeks, when the first examination was made, that the part did not require to be dressed again. If elevation of the patient's temperature indicated anything wrong in the early stages of healing, it would of course be better that protective silk had been used, as the dressing would be easier to remove. But even in that case, the very fact of something having gone sufficiently wrong locally to raise the temperature would probably in itself be fatal to the vitality of the grafts.

The question of the ultimate fate of the grafts from a histological point of view has been lately the subject of several investigations. According to Enderlen[1] the transplanted tissue gradually is removed and replaced by growth from below, and by the end of four weeks the grafts are almost entirely replaced. From a clinical point of view, however, the advantages of using grafts of the entire skin, as compared with those of epidermis only, are well established. The difference amounts to the difference between a normal skin surface and a cicatrix. The description, therefore, which Enderlen has given of the histological process is not what we should expect to be the case in consideration of the retention by the grafted piece of skin of the characters of skin. Thus, grafts cut from the skin of the thigh retain their hair follicles, as shown by the growth of fine hairs in the graft, although the part grafted, as in the case of the palmar surface, is normally destitute of

[1] Enderlen, "Ueber das Verhalten der elastischen Fasern in Hautpfropfungen," Virchow's *Jahresbericht*, 1898, i., p. 54.

hair. In view of this Braun[1] has recently studied the microscopic appearances of several of Krause's cases of grafting by this method. Small portions of the grafted skin at various stages were excised for examination, and he found that the structures of the transplanted cutis were almost *in toto* retained. The elastic and fibrillar tissue, papillae, hair follicles, glands, and muscle cells were all found to be retained at periods ranging from four days to three and a quarter years from the date of the operation. These also could not have been replaced from below, as the graft was found demarcated from the underlying parts by a true cicatricial tissue. This view is supported by Henle,[2] who describes the process of healing from experimental grafting in rabbits as follows: The early nutrition of the transplanted tissue is maintained entirely by transudation, but by the fourth day, as shown by injected preparations, the vessels of the graft are already included in the circulation. This is effected by outgrowth of capillary vessels from those of the tissue below the graft, which make connections with those of the graft. After this stage the healing process is simply that of healing *per primam*. The view thus expressed by Braun and by Henle is in accordance with clinical experience, and explains the superiority of grafts including the cutis vera over those which consist merely of epidermis.

In conclusion, I have to express my thanks to Dr. Patterson for allowing me to perform the operations in Cases 2 and 3 in his wards in the Western Infirmary.

[1] Braun, "Histologische Untersuchungen über die Anheilung Krause'scher Hautlappen," Langenbeck's *Archiv*, 1899, vol. lix., p. 340.

[2] Henle, "Verhandlungen der deutschen Gesellschaft für Chirurgie: XXVIII. Kongress," *Beilage zum Centralblatt für Chirurgie*, 1899, No. 27, p. 30.

PLATE I.

FIG. 1.

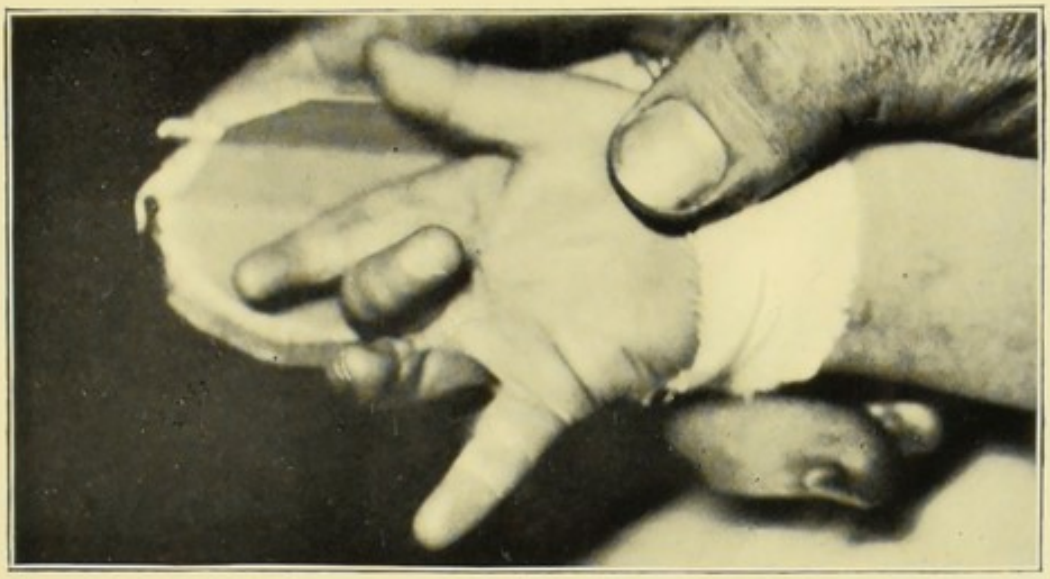

FIG. 2.

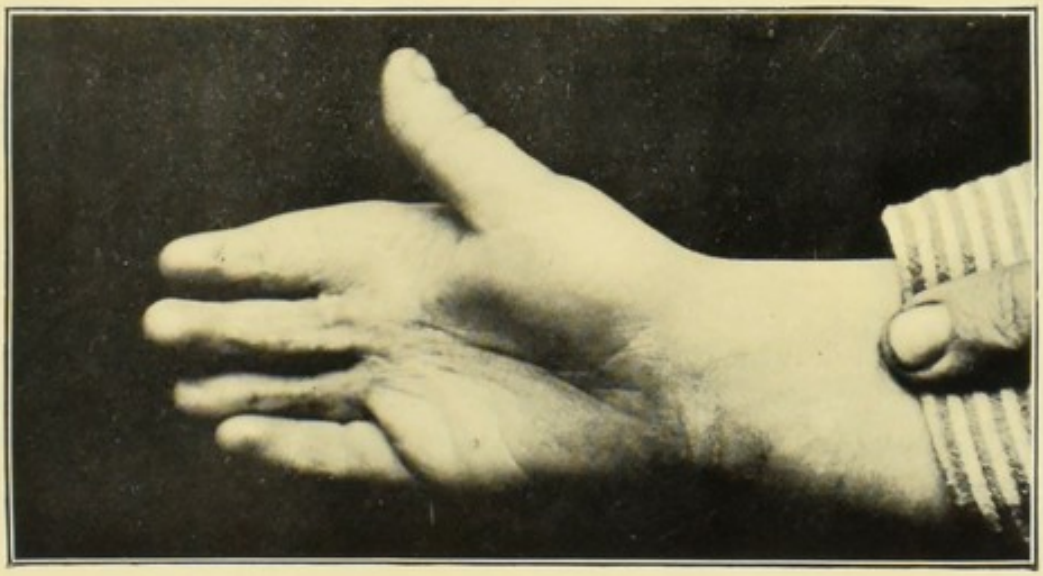

FIG. 3.

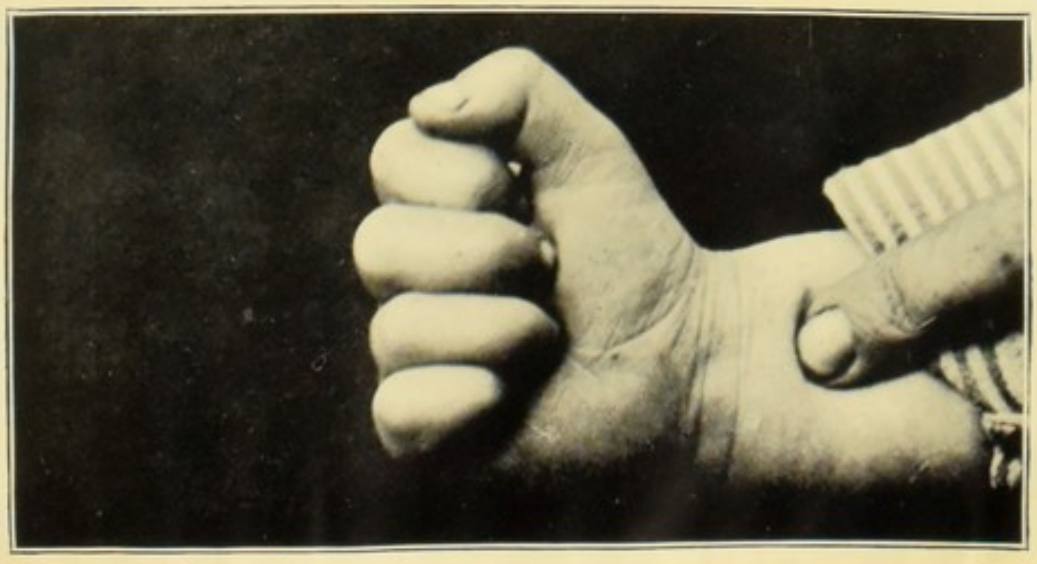

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PLATE II.

FIG. 4.

FIG. 5.

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EXPLANATION OF PLATES.

PLATE I.

FIG. 1. *Case* 2. Photograph of hand seven months after the first operation. The index finger still remains perfectly uncontracted, and the outlines of the transplanted skin flap are indicated. The ring finger is shown partially flexed, but this is caused chiefly by an adhesion to the middle finger. This finger also was grafted with a skin flap. The middle finger shows the condition of contraction completely reproduced, and this is the finger which was treated by Thiersch's epidermis graft.

FIGS. 2 and 3. *Case* 2. Hand, twenty-two months after the first, and fourteen months after the second operation. The index finger, which was not interfered with at the second operation, still remains uncontracted. The middle finger, which was treated with a transplanted skin flap, now remains almost uncontracted, and the same is the case with the ring finger. Fig. 2 shows the amount of voluntary extension, and Fig. 3 that of voluntary flexion.

PLATE II.

FIGS. 4 and 5. *Case* 3. Hand thirteen months after the operation. The grafted flaps on the ring and little fingers have in the photograph a somewhat cicatricial appearance, but this is due to the scaly quality of the skin. The little finger shows the shortening and rotatory displacement which were present before operation and which could not be remedied. Fig. 4 shows the degree of voluntary extension, and Fig. 5 that of voluntary flexion.