# THE KRUKENBERG STUMP

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There are very few industrial injuries, or congenital deformities, more depressing to the surgeon, and more disabling to the patient, than the loss of a hand. The unfortunate individual faces a dismal economic future unless something can be done to convert a useless extremity into one which can assume some independent motion.

The application of an artificial hand to a healed forearm stump, while creating a better cosmetic appearance, does little to aid the one who wears the prosthesis, although the palmar slot arrangement in the artificial hand permits the insertion of pencils, knives, forks and other appliances. If the forearm, however, could be converted into a grasping extremity, sensitive to tactile sensations, heat and cold, a result would be obtained far superior to any insensitive immobile artificial hand.

Krukenberg, in 1917, described an ingenious operation to serve this purpose, but, unfortunately, the procedure seems to be but little known. The operation is simple. It consists of dividing the forearm, separating the radius from the ulna, giving each bone an individual muscular supply and skin covering. The end result is not unlike the claw of a lobster in appearance. The ulna remains immobile while the radius revolves and retains its ability to pronate and supinate. This operation is much simpler than the various kineplastic procedures which have been advocated, and, when completed, a complicated prosthesis is not necessary. It has the additional advantage over the other kineplastic procedures that it may be done at the time of the traumatic amputation in selected cases. If desired, a simple artificial hand may subsequently be fitted, which not only answers a cosmetic purpose, but also proves useful because of a mobility of the hand, transmitted through the mobile radial stump. A working prosthesis has also been manufactured which will enable the wearer to actually perform very heavy manual labor. These appliances hide the stump and answer in part the argument that the mobile claw is extremely unsightly. There is no doubt that this statement is true but after all a forearm which is strong, sensitive, and useful certainly outweighs the aesthetic side of this industrial problem.

Krukenberg recommended that the stump be at least twelve centimeters long, but others—notably Biesalski—have been willing to do the operation with a shorter stump (eight centimeters). The technique of the operation is simple, and it is easily performed under a tourniquet. An excellent detailed description of the procedure is given in Bier, Braun, and Kümmell.[1] A brief résumé is herewith appended:

* From the Surgical Service of the Beekman Street Hospital, New York, N. Y., and the Orthopaedic Service of the Monmouth Memorial Hospital, Long Branch, New Jersey.

1. A U-shaped incision is made from the volar to the dorsal aspect of the forearm, slightly to the ulnar side, and over the attachment of the interosseus membrane to the ulna.

2. The dorsal incision is deepened to the extensor muscles. The extensor communis digitorum is identified, and the tendons to the second and third finger are sutured together. The tendons to the fourth and fifth fingers are similarly sutured. The extensor carpi ulnaris is left on the ulnar side. The brachioradialis and both extensor carpi radialis muscles are attached to the radius. The abductor pollicis longus, the extensor pollicis longus, and brevis are excised.

3. The volar incision is now deepened to the flexor muscles. The flexor carpi ulnaris and radialis are left on their respective sides. The divisions of flexor sublimis digitorum are treated similar to the extensor communis digitorum. The flexor profundus digitorum and the flexor longus pollicis are extirpated.

4. The median and ulnar nerves are identified and adequately resected and the stumps injected with alcohol.

5. The interosseus membrane is then slit *throughout* its length and removed, so that the radius and ulna are then separated for about twelve centimeters of their extent.

6. The flexor and extensor tendons are then sutured together over the radius and ulna respectively.

7. The radial stump as a rule may be covered with the overlying skin which is present.

8. It is very seldom, however, that there is sufficient integument to cover the ulna stump. It is usually advisable to do a pedicle skin graft to this stump from the side of the abdomen. This is best performed by making a skin flap and suturing it to the skin left on the ulna. The stump is immobilized to the abdominal wall for ten to twelve days. The skin flap is then freed from the abdomen and the closure completed.

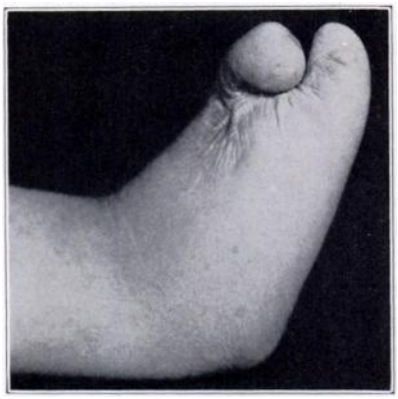

FIG. 1
Case 1. Claw closed.

FIG. 2
Case 1. Claw opened.

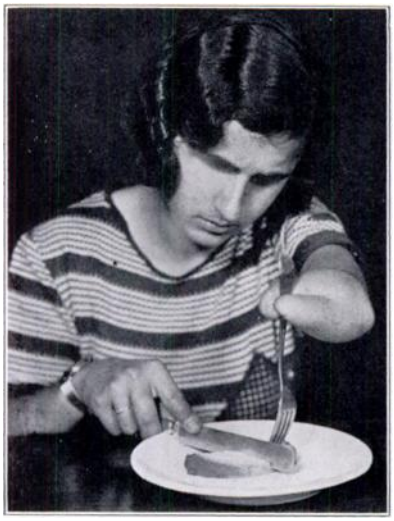

FIG. 3

Case 1. Showing how girl holds her fork. She is able to feed herself easily with this. She has excellent control of the fork.

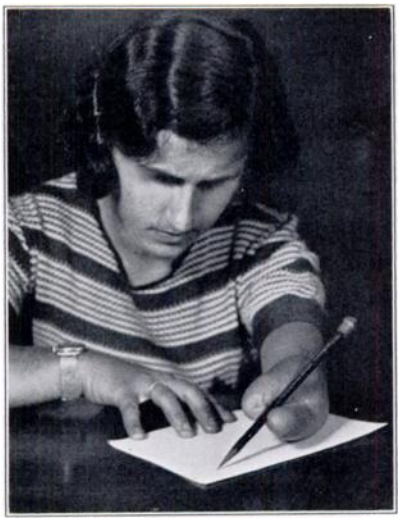

FIG. 4

Case 1. Showing her ability to grasp small objects, such as a pencil. She does not write with this, inasmuch as it is her left arm.

9. After the wounds have healed, active and passive exercises are begun, and pronation and supination are encouraged. After these motions are mastered, a pseudo-abduction and pseudo-adduction are apparent.

A very satisfactory mobile stump may be constructed by this method, and the histories of two patients which are herewith reported bear witness to the efficiency of the Krukenberg procedure.

CASE 1. J. B., aged fourteen, was admitted to the Monmouth Memorial Hospital at Long Branch, New Jersey, with a diagnosis of intra-uterine amputation of the left forearm.

The girl came to the clinic to inquire whether or not something might be done, or some prosthesis made, so that she might have some use of her left arm.

Her family history showed that she had a nephew with a congenital talipes equinovarus; otherwise the family history was negative.

She was admitted to the hospital December 17, 1929, at which time her physical examination was negative, except that it showed a stump of the left forearm, eight centimeters in length.

We realized that this would give a claw

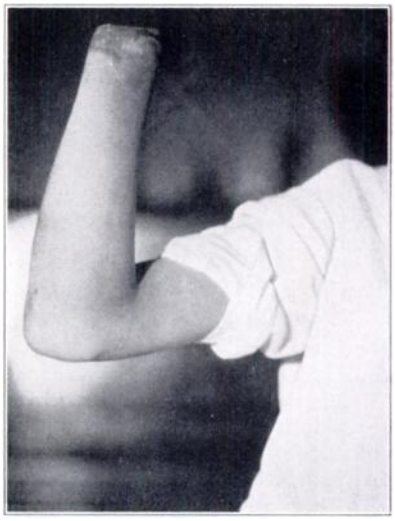

FIG. 5

Case 2. Showing forearm before Krukenberg amputation.

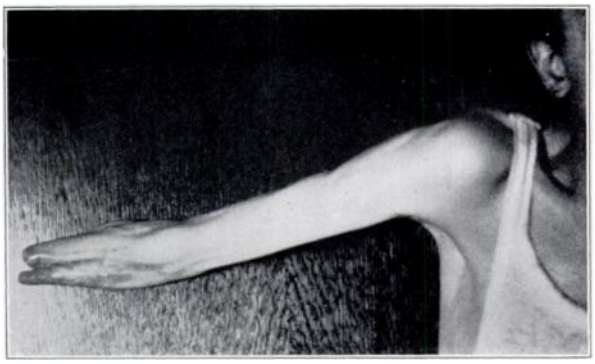

FIG. 6
Case 2. Showing Krukenberg claw in pronation.

FIG. 7
Case 2. Showing Krukenberg claw in supination.

FIG. 8
Case 2. Showing grasping power of claw.

with very short fingers. Under gas-oxygen-ether anaesthesia, a typical Krukenberg operation was done December 22, 1929. The one variation from the technique was that both the radial and ulnar components of the stump were enclosed in the original skin by a primary suture. This was a mistake, as both the suture lines sloughed out. Therefore, under narcosis, a pedicle skin graft was done March 2, 1930. The pedicle was removed from its base March 19, 1930, with a primary union of the graft. A pinch graft of the pedicle bed was done at the same time.

At the present time, she has a short but useful Krukenberg stump; there are pronation and supination which give the effect of adduction and abduction. She is able to grasp small objects and hold them firmly; she uses her left forearm to hold a fork while eating; and, in general, is very happy with the result.

CASE 2. R. T., a school boy, twelve years of age, was admitted to the Surgical Service of the Beekman Street Hospital October 27, 1930, and discharged January 21, 1931.

On the day of admission, the patient held an ignited torpedo in his hand, which subsequently exploded. He was immediately brought to the hospital.

Physical examination disclosed a maceration and avulsion of the entire right hand up to and including the wrist joint, so that no bones were spared in the destruction. There were also powder wounds which extended through the skin into the soft parts, over the lateral aspect of the arm on the same side, to the mid-brachial region.

Under ether anaesthesia, an amputation of the right hand and wrist was performed through the carporadial articulation. The periosteum of the radius and ulna was not disturbed. The skin was trimmed for a considerable distance and the parts remaining looked very clean. The whole area was thoroughly irrigated with saline and a few

chromic sutures approximated the muscle and fascial elements over the ends of the bone, the skin being closed with a few submarine silk sutures. At the same time a débridement was also done on the powder wounds of the arm. Two pieces of iodoform gauze were inserted into the defects of the arm and the wound dressed dry.

There was considerable sloughing following the procedure, but under dakinization the stump was clean enough for a thiersch graft on November 21, 1930. This was subsequently supplemented by pinch grafts. The forearm was ready for a Krukenberg plastic operation on January 21, 1931.

On January 28, 1931, the wound was dressed. The skin flap around the stump of the radius had sloughed, while the pedicle flap to the ulna was viable.

On February 11, under general anaesthesia, the pedicle to the graft was divided and sutured about the ulna, although part of it remained uncovered.

On February 25, under anaesthesia, pinch grafts were taken from the right anterior femoral region and placed on the granulating area over the radius and parts of the ulna, and paresine dressing applied.

On March 4, 1931, the boy had amazing grasping power of the stump. The ulna was practically healed and about thirty per cent. of the pinch grafts of the radius had taken.

The patient was discharged on March 11, 1931, at which time the stumps had practically healed. There was complete extension at the elbow and the patient had good grasping power of the stumps. Since that time patient has been seen on many occasions. He has complete flexion and extension of the elbow; pronation and supination of the radius about the ulna is complete, although abduction and adduction of the radial stump are practically negligible.

1. Bier, A., Braun, H., und Kümmell, H.: Chirurgische Operationslehre. Leipzig, J. A. Barth, V, 225, 1912.