

Krukenberg Operation: Revisited

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Abstract

The hand serves as a highly efficient and adaptable tool capable of performing extremely delicate as well as strong tasks with ease. It is an organ not only of sensation but also of expression. Therefore, loss of hand causes more handicap than the loss of leg. It is a well-recognized fact that even the most sophisticated upper limb prosthesis cannot match the functions of hand.

In view of above, importance of Krukenberg operation, for reconstruction of non-functional below elbow stump, into a highly functional and sensate organ, to compensate for the loss of functions of upper limb, cannot be over emphasized. However, there are very few centres in the world where this operation is performed. As it requires skill and expertise to perform the operation and results are good only in expert hands.

Key Words : Krukenberg Operation; Below Elbow Amputation, Functional and Sensate organ, Rehabilitation.

Introduction

The hand is one of the most complex anatomical mechanisms, which performs a variety of complex functions with minimal conscious effort. As no prosthesis can ever compensate for all functions of the hand, its loss leads to devastating consequences. Loss of one-hand results in severe degree of handicap and it increases exponentially with loss of both the hands (1).

Amputee rehabilitation is not solely the provision of prosthesis rather it is the restorative intervention necessary to return the patient who has had an amputation to the highest level of functioning to minimise the impact of amputation on his or her life (2).

In 1917 Krukenberg described a technique that converts a forearm stump into a pincer that is motorized by the pronator teres muscle. In this operation radius and ulna are separated into the two jaws of a "crocodile" forceps, with tactile sensibility. Indications mostly include bilateral upper-extremity amputations, especially in those who are also blind. The procedure has also been used successfully in developing countries who lack the means to obtain expensive prostheses (3).

This procedure preserves proprioception and stereognosis in the functional stump to allow for effective



maneuvering in the dark. It is important to note that this procedure is not recommended as a primary procedure at the time of an amputation, and the procedure must be preceded with appropriate counseling due to cosmetic concerns. Conversely, once this procedure is performed, it does not preclude the use of a functional prosthesis. Therefore, the patient is offered the option to use either functional strategy (4).



To consider this surgical option, the ulna and radius must extend distal to most of the pronator teres (the motor for pinching) and an elbow flexion contracture if present

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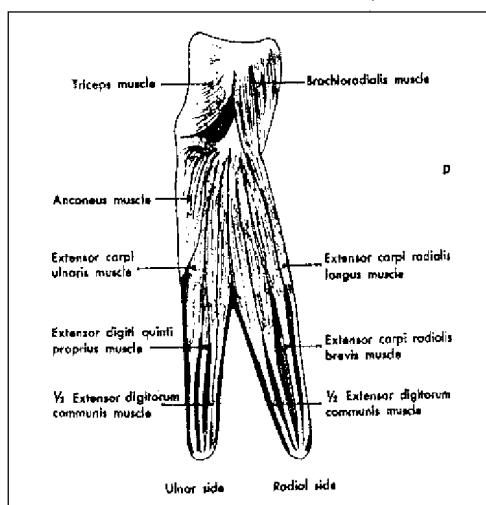
should be of less than 70°. Swanson and Swanson, Nathan and Trung and Garst described several modifications of Krukenberg's original surgical technique, focusing on conservative debulking and flap closure without the need for skin grafts. The success of this procedure depends directly on the strength of the pronator teres, the sensibility of the skin surrounding both ulna and radius, elbow mobility, and mobility of the ulna and radius at the proximal radioulnar joint. Individual patient expectations and motivations, although more difficult to assess, probably play a major role in outcomes as well (5).

Material & Method

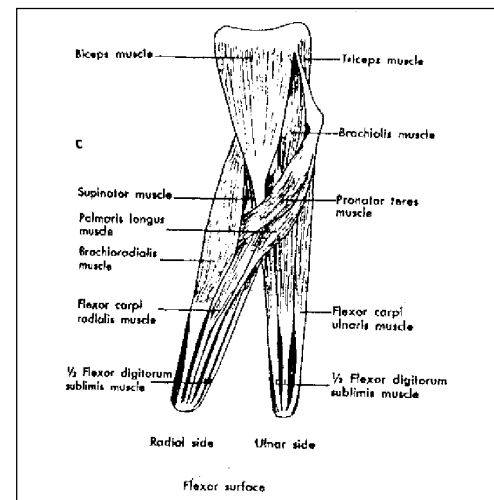
A total of eighteen below elbow amputees underwent Krukenberg operation at Artificial Limb Centre, Pune in a period of six years from Jan 1998 to Dec 2003. These patients were evaluated for their suitability for Krukenberg procedure. Prerequisites for Krukenberg procedures were: -

- (a) Below elbow stump should have minimum length of 20 cm.
- (b) Stump should exhibit full range of flexion, extension, supination and pronation, with good strength.
- (c) Stump should have fully functional pronators.

Pre-operatively below elbow amputation stump, was examined thoroughly for adequate vascularity, availability of healthy skin, adequacy of length, strength of muscles and movements at elbow and radio ulnar joints.

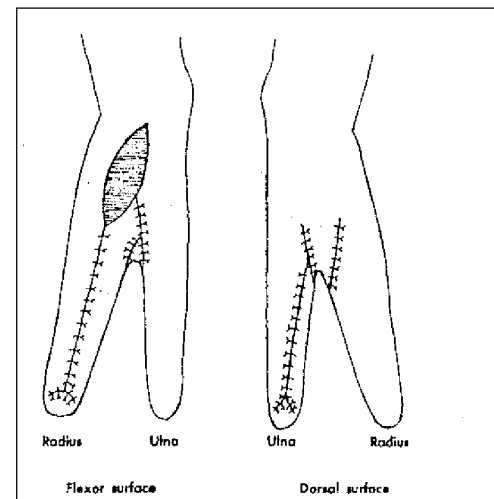


For ideal Krukenberg stumps, length of base from elbow crease should be 8 cm and length of two prongs should be 12 cm from base. The skin incision was placed 1 cm medial to midline anteriorly. The incision was turned laterally by 90° at its proximal end. On the posterior aspect, the incision was made in the midline and its proximal end was turned medially at right angle. Distally, both incisions were joined in midline at tip of stump.



Incisions were deepened and muscles were separated into two equal halves. The flexor digitorum sublimis and flexor digitorum profundus were also separated by blunt dissection. A similar procedure was carried out on posterior aspect.

Interosseous membrane was divided to separate radial and ulnar prongs gently. Precaution was taken to avoid injury to Interosseous vessels.



Both bones were divided at the same level. The muscles were sutured over the tip of the bones. Radial stump was closed by 'Z' plasty. A split skin graft was placed to close ulnar stump without tension. Suction drain was placed separately in both stumps and operative wounds were dressed keeping both prongs separated as much as possible. Drainage tubes were removed on third day. First dressing was changed on fifth day and second on tenth day. Skin sutures were removed after 2 weeks.

Training was started immediately after wound healing, to re-educate movements of pronation and supination in closing and opening movements of the radial and ulnar stumps to achieve pincer and grasping effects. All patients were given training in activities of daily living and for other works.

Results

Most of our patients were young male of 25-35 years (61%)[Table 1]. Thresher injury was the main cause of below elbow amputation in the patients who underwent Krukenberg operation (33 %) followed by frost-bite (28 %)[Table 2]. 33 % of the cases were bilateral below elbow amputees [Table 3]. Postoperative

skin flap necrosis developed in 33 % patients, while 5.55 % of them developed necrosis of tip of bones [Table 4]. 17 % patients had temporary loss of pincer action of Krukenberg stumps. In these cases pincer function improved by electric stimulation of pronator teres muscle. Results were satisfactory in all cases as no patient developed permanent loss of pincer effect [Table 5].

TABLE 1. AGE DISTRIBUTION

S. No.	AGE	No	% OF CASES
01.	15-25 Yrs	4	22.22%
02.	25-35 Yrs	11	61.11%
03.	Above 35 Yrs	3	16.67%

TABLE 2. CAUSES OF AMPUTATION

S.No.	CAUSE	No	% OF CASES
01.	Road Traffic Accident	3	16.67%
02.	Blast Injury	3	16.67%
03.	Gangrene	1	5.55%
04.	Frost Bite	5	27.78%
05.	Thresher Injury	6	33.33%

TABLE 3. LATERALITY

S. No.	SIDE	No	% OF CASES
01.	Unilateral	12	66.67%
02.	Bilateral	6	33.33%

TABLE 4. POST OPERATIVE COMPLICATIONS

S. No.	COMPLICATION	No	% OF CASE S
01.	Necrosis of Flap	6	33.33%
02.	Necrosis of tip of bone	1	5.55%
03.	Temporary loss of Pincer action of prongs	3	16.67%
04.	Permanent loss of Pincer effects of prongs	Nil	Nil

TABLE 5. OUT COME OF OPERATION

S. No.	OUTCOME	GOOD	SATISFACTORY	POOR
01.	Pincer effect of prongs	66.67	33.33%	Nil
02.	Ability to do activity of daily living	61.11%	38.89%	Nil
03.	Sensory perception by prongs	100%	-	-

Discussion

Amputation continues to represent a major health and socio-economic problem. In Western Countries, vascular insufficiency and diabetes make major etiological groups (6,7), while in our country trauma is the major cause of amputation (8). Accident is the main cause of the upper extremity amputations and most of these occur in young males (9).

Loss of hand results in lack of grasp and sensation. The higher the level of amputation, greater is the functional loss. An upper limb with limited motion, multiple scars or lack of sensations, functions poorly because of the constant risk of tissue injury. This type of limb often

functions worse than a modern prosthetic replacement (10).

Loss of one hand results in severe degree of handicap. It not only causes physical disablement but also leads to social, psychological and economical handicap (11). Handicap is multiplied with loss of both hands.

The Krukenberg procedure of converting two non-functional below elbow stumps into sensitive and functional organs make double hand amputee a totally independent individual. In such an amputee who has also lost his vision, the procedure is of vital importance (12). Krukenberg devised this procedure in 1917. However, the procedure fell in to disrepute due to its

unsightly appearance but its functional capabilities overshadowed all its negative points (13). The Krukenberg operation has been performed regularly at artificial limb centre, and more than 200 operations have been done since 1950(14).

Ratio of upper limb to lower limb amputation, in USA is 1: 4.9 (15), while it is 1: 9 in India. In UK, arm amputation accounts for only 3 % of the total amputation referred for prosthetic rehabilitation.

The most frequent causes of upper limb amputation are trauma and cancer followed by vascular complication of disease in USA (16). In our Country more than 2/3 upper limb amputation are due to trauma. The most common upper limb amputation is at the trans-radial level, which account for 57% of all upper limb amputations. Trans-humeral amputation accounts for 23% of all amputations. The right hand is more frequently involved in work related injuries.

Krukenberg operation is rarely performed in Great Britain. It has been more commonly performed in Germany and India with good results (17). Schmidt A et al (Shriner's Hospitals for Children, Los Angeles) found that although medical practitioners in North America consider the Krukenberg procedure to be too unattractive to outweigh the superior functional results, non-medical people do not share this opinion. Thus, medical practitioners should offer the procedure as a viable option to prosthetic use and allow each patient (and family) to come to their own decision (18).

Conclusion

Results of Krukenberg reconstructive procedure on a below elbow stump to provide grip, grasp and pinching mechanism with sensation have been found to be so gratifying that the patients disregard the alleged poor appearance and most patients accept the Krukenberg procedure.

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