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General

MICROSURGICAL REIMPLANTATION OUTCOMES FOR COMPLETE AND INCOMPLETE AMPUTATIONS OF DISTAL PHALANGES OF FINGERS

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Introduction

The intricate endeavor of replanting the distal phalanx of the finger remains a persistent challenge. In the pursuit of addressing this concern, microsurgical replantation procedures have been systematically examined for distal phalanx injuries encircling the distal interphalangeal (DIP) joint, conducted at the Orthopaedic Hospital situated in Ho Chi Minh City.

Materials and Methods

This investigation encompassed a cohort of 31 patients, comprising individuals with 17 instances of complete and 21 instances of incomplete amputations of the distal phalanges. The subjects' ages spanned a range from 3 to 56 years.

Results

The study divulged that eight fingers, involving four complete amputations and four incomplete amputations, did not achieve successful outcomes. In contrast, the remaining 30 fingers exhibited survival. A meticulous long-term follow-up of 17 fingers, extending over a period exceeding six months, unveiled commendable achievements encompassing satisfactory sensory recovery, cosmetic enhancement, and the resumption of pre-injury occupational activities by the patients.

Discussion

Vein anastomosis was revealed as a notably challenging aspect of the surgical procedures. In scenarios where conventional vein suturing was rendered unfeasible, the innovative recourse of one-way drainage emerged as a viable alternative.

Conclusion

The endeavor to replant the distal phalanx of the finger engenders a substantial level of complexity, particularly in the realm of venous anastomosis. This research underscores the need for focused efforts to address and surmount the intricacies associated with this aspect of surgical intervention.

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I. INTRODUCTION

Finger amputations represent a prevalent occurrence within the clinical realm.[1-3] Although the replantation of distal phalanges may not invariably hold precedence due to its intricate nature and relatively limited functional compromise, its significance in preserving overall hand function cannot be overstated. This is particularly pronounced in cases concerning individuals with professions reliant on meticulous fingertip dexterity, such as pianists or computer engineers, underscoring the imperative of distal phalanx preservation.

The application of microsurgical techniques in the realm of finger replantation has yielded commendable outcomes, as evidenced by endeavors undertaken at the Hospital for Traumatology and Orthopaedics situated in Ho Chi Minh City.[1,2] However, the intricacies surrounding the replantation of the distal phalanx persist as a formidable challenge. This challenge is primarily attributed to the restricted vascularity inherent to this region and the concomitant inadequacy of venous inflow. Given these multifaceted impediments, there emerges an exigent requirement for a dedicated inquiry into the domain of distal phalanx replantation, a research endeavor poised to adequately address societal needs and contribute significantly to the enhancement of surgical interventions within this intricate arena.

RESEARCH OBJECTIVES

Evaluation of Distal Phalanx Replantation Outcomes:

Identify primary difficulties and potential solutions.

II. OBJECTIVES AND METHODS

STUDY SUBJECTS

The study encompassed cases of both complete and incomplete distal phalanx amputations that fell within the parameters of recoverability within the designated ischemic time frame.

EXCLUSION CRITERIA

Amputations confined to the capillary level were excluded from consideration, as were instances involving severely crushed distal phalanges.

EQUIPMENT

The research was conducted employing an array of specialized equipment, including a microscope endowed with magnification capabilities exceeding 10 times. Microsurgery forceps, characterized by an ultrafine tip measuring less than 0.2mm, were employed for precise manipulation. Sutures of both 10.0 and 11.0 nylons were utilized to facilitate the intricate surgical procedures.

METHODS

The study adopted a case series design, characterized by its systematic exploration of distal phalanx replantation techniques. These methodologies encompassed a series of procedural steps, commencing with meticulous wound cleaning and extending to pivotal aspects such as bone fixation, tendon repair, anastomosis, nerve repair, and eventual skin closure. This comprehensive approach facilitated a holistic investigation into the intricacies of distal phalanx replantation, thus contributing to a more comprehensive understanding of the procedural nuances and outcomes associated with this intricate surgical intervention.

III. RESULTS

The present study encompassed a total of 31 cases involving 38 individual fingers. Among the study participants, 23 were male and 8 were female, resulting in a gender distribution of 74.2% males and 25.8% females. The age range of the participants extended from 3 to 56 years, with a mean age that fell within the spectrum of adult life. Stratification of age cohorts revealed that 4 cases (12.9%) were below 15 years old, 6 cases (19.4%) were within the 16–25 age range, 13 cases (41.9%) fell between the ages of 25 and 40, and 8 cases (25.8%) pertained to individuals above the age of 40.

MECHANISMS OF INJURY AND LOCATION

The mechanisms responsible for the injuries were diverse, with 11 cases (35.5%) attributed to crushing forces, 14 cases (45.2%) to cutting events, and 6 cases (19.3%) to avulsion incidents. In terms of the side of injury, there was a relatively balanced distribution, with 17 cases (54.8%) affecting the right side and 14 cases (45.2%) involving the left side.

AMPUTATION TYPES AND DISTRIBUTION

Regarding the types of amputations, the study identified 13 cases (41.9%) characterized by complete amputations, while the remaining 18 cases (58.1%) were classified as incomplete amputations. Analysis of the amputation distribution further elucidated the extent of hand involvement. Specifically, 3 cases (9.7%) demonstrated amputation of 3 fingers per hand, an equivalent number of cases (9.7%) involved 2 fingers per hand, and the most frequent configuration, observed in 25 cases (80.6%), was a single finger amputation per hand.

The distribution of complete and incomplete amputations across various fingers within the study cohort is presented in the following table. The table encompasses the enumeration of occurrences for each finger type, specifically identified as I, II, III, IV, and V. The term “complete” refers to complete amputations, while “uncomplete” pertains to incomplete amputations.

Table 1 illuminates the distribution of complete and incomplete amputations across different fingers within the studied population. Notably, finger II exhibited the highest frequency of incomplete amputations with 6 occurrences, while finger III manifested the least prevalence of such in-

Table 1. the distribution of complete and incomplete amputations across different fingers within the studied population

Finger	Complete	Incomplete
I	4	4
II	4	6
III	2	4
IV	4	5
V	3	2
Sum	**17**	**21**

cidents, amounting to 2 cases. On the other hand, fingers I, IV, and V displayed comparable distribution patterns for both complete and incomplete amputations. The cumulative sum reflects a total of 17 complete amputations and 21 incomplete amputations across the entire dataset.

FRACTURE DISTRIBUTION AND BONE FIXATION

Among the analyzed cases, a detailed assessment of fractures and associated bone fixation strategies is presented. Fracture incidence differentiated by the presence or absence of articular surface injury revealed that 21 cases displayed fractures without articular surface involvement, whereas 17 cases exhibited fractures with concomitant articular surface injury. In the context of bone fixation modalities, the implementation of K-wire fixation was observed in 38 fingers, while fusion techniques were employed in 13 cases.

ANASTOMOSES TECHNIQUES

The breakdown of amputation types and subsequent anastomosis methods is as follows:

For Complete Amputation:

In cases of complete amputation (Figure 2), where the entire finger is severed, the following anastomosis methods were employed:

- Two arteries and two veins anastomosis: 1 finger
- One artery and three veins anastomosis: 3 fingers
- One artery and two veins anastomosis: 6 fingers
- One artery and one vein anastomosis: 4 fingers
- One artery and zero vein anastomosis: 3 fingers
- One-way drainage method via finger nail incision: 5 fingers
- Arterial grafting: 3 fingers
- Transfer of arterial source: 6 fingers
- Cross-transfer of artery: 5 fingers
- Transfer to contiguous artery: 1 finger
- Venous grafting: 5 fingers

For Incomplete Amputation (Figure 1):

In cases of incomplete amputation, where a portion of the finger is retained, the following anastomosis methods were applied to all 21 fingers:

- One artery anastomosis: 21 fingers

Figure 1. A case of incomplete distal phalanx amputation, the approach to vascular anastomosis typically involves the connection of a single artery. Additionally, a method involving the cutting of the finger nail is employed for the purpose of drainage. This strategy aids in addressing the unique challenges posed by incomplete amputations, facilitating appropriate vascular perfusion and postoperative management.

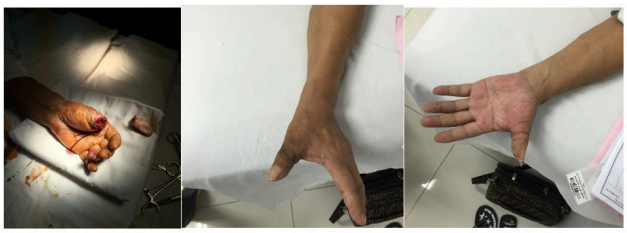

Figure 2. The presented case involves a patient who sustained a crush injury resulting in the complete amputation of the distal part of the left index finger. The patient underwent operative intervention approximately 4 hours after the accident. The surgical procedure encompassed microsurgical techniques, with a specific focus on arterial anastomosis performed under microscopic guidance. Furthermore, a one-way drainage approach was implemented, involving the cutting of the finger nail. Subsequent to the surgery, a regimen of daily Heparin administration via drops was instituted. This comprehensive approach aims to address the complex challenges inherent to crush injuries and complete amputations, ensuring optimal vascularization and effective postoperative care

- Two vein anastomoses: 3 fingers
- One vein anastomosis: 7 fingers
- Venous grafting: 5 fingers
- Failure to anastomose vein: 6 fingers

NERVE REPAIR AND SURVIVAL OUTCOMES

In cases of complete amputation, 9 out of 17 fingers received repair for two nerves, while 8 fingers underwent repair for a single nerve. Similarly, in fingers of incomplete amputation, 8 out of 21 cases underwent repair for two nerves, and 13 fingers involved repair of a single nerve. Notably, 8 fingers within the incomplete amputation group exhibited one-sided nerve damage.

SURVIVAL RESULTS AND LONG-TERM FOLLOW-UP

Overall, in terms of case survival, 25 out of 31 cases demonstrated successful outcomes, while 6 cases experienced necrosis. By considering individual fingers, complete amputation cases yielded a survival rate of 76.4%, while incomplete amputation cases showcased a higher survival rate of 81.0%. The cumulative survival rate across all analyzed fingers was 78.9%.

A more extended follow-up analysis encompassing a duration of over 6 months involved 17 cases. Among these cases, observations revealed that 8 out of 17 fingers presented impaired finger nutrition, while sensation at the tip of the finger was recorded as S2 in 3 cases and S3 or higher in 14 cases. In terms of range of motion (ROM), 9 cases exhibited stiffness at 30-60 degrees, and 8 cases demonstrated stiffness at other degrees. All 17 fingers demonstrated the capacity to utilize the finger for work, and 16 cases successfully resumed their previous occupations. Additionally, patient satisfaction was universally recorded in all 17 cases.

In conclusion, the comprehensive evaluation of orthopedic parameters and outcomes underscores the complexity of various amputation types, fixation techniques, anastomoses strategies, nerve repairs, and subsequent survival and functional restoration outcomes. The presented data shed light on the intricacies of these parameters in the context of finger replantation, emphasizing the multifaceted challenges and successes observed within this domain.

IV. DISCUSSION

EPIDEMIOLOGY

In our dataset, the preponderance of patients comprised males, accounting for 23 out of 31 cases. The age distribution was concentrated within the labor-age demographic, with 19 out of 31 cases falling between 16 and 40 years. This demographic trend underscores the potential ramifications of phalanx loss, as it can result in both occupational incapacity and aesthetic impairment. Notably, among these cases, the cohort encompassed individuals engaged in specialized occupations, including two musical artists and three individuals reliant on meticulous manual tasks, thereby highlighting the critical role of fingertip functionality. Moreover, the inclusion of patients under 15 years of age underscores the pervasiveness of this injury across various age groups, as evidenced by a case involving a three-year-old child impacted by a machine propeller incident. Mechanistically, the etiology of injury was consistently attributed to high-energy force events, encompassing cutting, battering, and wrapping, culminating in complex multi-level crush injuries. The resultant intricacies associated with phalanx replantation and the constrained outcomes vis-à-vis more straightforward cutting injuries necessitate careful consideration.

INDICATIONS FOR DISTAL PHALANX REPLANTATION

In light of hand functionality, the thumb emerges as the foremost contributor, accounting for 40-60% of hand function, while the remaining four fingers collectively contribute between 10-15%. Consequently, thumb amputation warrants priority for replantation, surpassing the other four fingers, which are prioritized based on vocational requirements. Noteworthy distinctions are made in our research, whereby priority considerations are extended to children and unmarried females to mitigate potential psychological distress and unfavorable cosmetic outcomes.

SURVIVAL RATE

The minute caliber of vessels at the distal phalanx, often measuring below 0.5mm, necessitates meticulous attention and expertise in their anastomosis, akin to super-microsurgery techniques. Reflecting this exigency, the successful execution of anastomosis mandates the involvement of experienced microsurgeons, well-equipped with fine microsurgical instruments. Within our study, a cadre of youthful and enthusiastic microsurgeons undertook the procedures, further bolstered by the endorsement of employing suture 11.0 for microanastomosis of minute vessels. Survival rates post-replantation reveal that 13 out of 17 fingers with complete amputation achieved unblemished survival, translating to a success rate of 76.4%. Likewise, 17 out of 21 fingers subjected to incomplete amputation exhibited flawless survival, resulting in an 81.0% success rate. The cumulative survival rate across both categories culminated at 78.9%. Comparative contextualization with prior research indicates concurrence with acceptable survival rates set forth by established authors, including Chien-Tzung Chen[4] in 1994, who achieved a survival rate of 78%, and Yoshiki Yamano's 1994 study[5] reporting an 84.6% survival rate.

ARTERIAL ANASTOMOSIS AND ITS CHALLENGES

While arterial anastomosis generally presents less complexity than venous anastomosis, challenges persist, particularly concerning the diminutive nature of arteries and their susceptibility to crushing. Strategies employed in cases of shortened amputation phalanges encompass transferring arterial sources from proximal regions or utilizing venous grafts to mitigate suture tension. A subgroup of cases involved transferring arterial sources, of which five instances experienced non-uniform arterial transections due to oblique injury. To circumvent tension-induced complications, cross anastomosis between the distal portion of an artery and the contralateral proximal segment was adopted. An illustrative case involved reimplanting the distal phalanx of the thumb, necessitating the use of an arterial source from the radial aspect of the index finger. This source was then relocated to the thumb and anastomosed with the distal portion of the thumb artery. Addressing arterial loss involved grafting from the venous conduit to obviate tension during suturing.

VENOUS ANASTOMOSIS AND ITS CHALLENGES

The endeavor of venous anastomosis at the distal joint level poses formidable challenges due to the diminutive and delicate nature of veins. Despite best efforts, successful venous anastomosis remains a complex task, with instances occasionally accommodating only a single venous anastomosis. Skin loss in select cases necessitated vein grafts to ensure efficient return blood flow. Intriguingly, certain incomplete amputation cases encountered difficulties in venous anastomosis due to injury proximity to the nail. In these instances, residual skin flaps precluded conventional approaches, leading to the decision to forego nail or fishmouth incisions. In cases of complete amputation, difficulties persisted, compelling the adoption of fishmouth cutting and daily heparin administration over a five-day period as a one-way drainage approach. The consensus among multiple authors underscores the arduous nature of venous anastomosis, particularly within the confines of the distal phalanx region, warranting innovative approaches such as leeches or nail cutting for drainage, even at the expense of potential blood loss and heparin use.

FUNCTIONAL RECOVERY

Follow-up spanning more than six months for 17 cases unveiled intriguing findings. Specifically, only three cases exhibited sensitive recovery at S2, while an overwhelming majority of 14 cases displayed recovery at the S3 level or higher, indicative of a discernible 2-point discrimination, thermal sensitivity, and shape discrimination capacity. This facet is integral to the crucial attributes of the distal phalanx replantation procedure. The contrast with local flap interventions, which demonstrate inferior sensitive recovery outcomes, underscores the value of preserving sensitive receptors at the fingertip through replantation. Notably, acclaimed researchers Yoshiki Yamano[5] and Keming Wang[6] align with these observations in their post-operative patient follow-ups. Consequently, a consistent emphasis on nerve repair has been maintained in our cases. In terms of range of motion (ROM), several cases displayed stiffness in flexion at 30-60 degrees, attributable to either joint surface injury or inadequate postoperative exercise. Although complete restoration of hand function remains unattainable post-distal phalanx replantation, patient satisfaction remains remarkably high, facilitating their successful reintegration into work-related endeavors.

Initial results of distal phalanx replantation highlight the complexities and varied scenarios involved, particularly in venous anastomosis. Skillful technique and problem-solving abilities are critical for achieving positive outcomes.

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