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AGAINST ALL ODDS: TRAUMATIC THUMB AMPUTATION FOLLOWING RING AVULSION INJURY

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Background. Replantation of an avulsed digit often poses a surgical challenge even to an experienced microsurgeon. Therefore, it is often difficult to choose the treatment path for traumatic amputation of digit following ring avulsion injury, be it completion amputation or replantation. We discuss the surgical challenges encountered and management strategies used in this case of an unfortunate child who sustained an amputation of his dominant thumb.

Clinical case. We present the case of a 10-year-old boy who sustained a complete amputation of his right thumb following a ring avulsion injury which was reconstructed with multiple approaches and surgical techniques to address difficulties at different stages. We replanted the avulsed thumb, reconstructed the tendon, soft tissue coverage with the use of allograft skin and local flap, and improvised surgical tactic to overcome complications encountered intra- and post-operative states such as thrombosis of arterial anastomosis and venous congestion.

Discussion. There is scarce literature on the management of ring avulsion injury of the thumb and to the author's best knowledge, there was only one reported case in children. In the case described here, we report a good outcome with complex reconstructive surgery despite all odds in an attempt to salvage the thumb, especially in a pediatric population. Post-surgical reconstruction, the boy achieved a successful and acceptable outcome in terms of function and aesthetic appearance.

Conclusion. The journey through replantation of an amputated digit following avulsion injury poses various challenges both to the microsurgeon and patient. The decision of surgical tactics must be tailored and thoroughly reason based on the knowledge, experience, and good microsurgical skill. A good surgical outcome can be achieved even in a complex injury in the pediatric population with careful planning and the right intervention in each complication peri-operative.

Keywords: thumb amputation; ring avulsion injury; thumb replantation; tendon transfer; FDMA flap.

ВОПРЕКИ ВСЕМ ПРОГНОЗАМ: ТРАВМАТИЧЕСКАЯ АМПУТАЦИЯ БОЛЬШОГО ПАЛЬЦА ПРИ ТРАКЦИОННОМ ПОВРЕЖДЕНИИ КОЛЬЦОМ

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Обоснование. Реплантация ампутированного пальца часто представляет сложную хирургическую задачу даже для опытного микрохирурга. В связи с этим во многих случаях трудно определить оптимальную тактику лечения при травматической ампутации пальца при тракционном повреждении кольцом — будет это завершение ампутации или реплантация. В данной статье мы рассмотрим хирургические сложности и методы лечения у ребенка с ампутацией большого пальца доминирующей руки.

Клиническое наблюдение. Представляем случай ампутации большого пальца у 10-летнего ребенка при тракционном повреждении кольцом. Палец реплантирован с использованием различных методик и хирургических подходов. Мы реплантировали ампутированный большой палец, сшили сухожилие и восстановили мягкие ткани с применением кожного аллотрансплантата и местного лоскута, придерживались нестандартной хирургической тактики для борьбы с осложнениями, возникшими во время операции и в послеоперационном периоде, такими как тромбоз артериального анастомоза и венозный застой.

Обсуждение. Публикации по лечению тракционного повреждения большого пальца кольцом немногочисленны, и, по нашим сведениям, есть только одно сообщение о нем у детей. В приведенном клиническом случае описана сложная реконструктивно-пластическая операция с благоприятным исходом, несмотря на то что прогнозы в отношении большого пальца неблагоприятные, особенно у детей. Благодаря послеоперационной реконструкции получен успешный и приемлемый функциональный и эстетический результат.

Заключение. Реплантация ампутированного пальца при тракционном повреждении представляет значительную сложность как для микрохирурга, так и для пациента. Выбор хирургической тактики должен быть индивидуален и тщательно обоснован с учетом знаний, опыта и микрохирургических навыков. Хорошего результата хирургического лечения можно достичь даже при сложном повреждении у детей в случае тщательного планирования и выбора оптимального алгоритма действия при каждом периоперационном осложнении.

Ключевые слова: ампутация большого пальца; тракционное повреждение кольцом; реплантация большого пальца; транспозиция сухожилия; лоскут из бассейна первой тыльной пястной артерии.

Ring avulsion injury of the digit is described as an injury sustained to the digit after it is pulled within a ring or a ring-like structure. It presents with a wide range of severity, from simple laceration wound to complete degloving of the digit or digit amputation. While the severity of ring avulsion injury is directly related to the amount of force involved, only minimal force is needed to result in one.

The Urbaniak classification is the most frequently used system to categorize ring avulsion injuries, dividing it into 3 classes — Class I (circulation adequate), Class II (circulation inadequate) and Class III (complete degloving or complete amputation) [1]. Certainly, the treatment strategies differ according to the severity of the injury. The choice of completion amputation and digit replantation are the common treatment juncture following Urbaniak Class III injuries. While a viable replanted digit is the main objective of digit replantation in the early days following the first human digit replantation by Komatsu and Tamai in 1968 [2], the focus is now shifted towards the return of function following replantation, with current indications for digit replantation is tailored according to findings from functional outcome studies [3].

We report a case of successful replantation of thumb following Urbaniak Class III ring avulsion injury along with the challenges it posed and its functional outcome.

Clinical case

A 10 years old boy presents at 3 hours post-trauma with Urbaniak Class III ring avulsion injury of his right thumb (Fig. 1, *a*), sustained in a mishap while handling a heavy sports equipment. He is right-handed and otherwise healthy. Physical examination revealed a complete amputation of the right thumb at the level of the distal aspect of the proximal phalanx. The flexor policis longus (FPL) tendon was avulsed at the musculotendinous junction and remain attached to the amputated portion (Fig. 1, *b*). He was subsequently pushed to the operating theatre 5 hours later (8 hours post-trauma).

After stabilization with K-wires, the FPL tendon was tunneled back through its flexor sheath with its proximal end tagged with blue Prolene 4/0 suture and banked-in at Zone 5 (proximal to the wrist) for future repair. The ulnar digital artery (UDA) was explored and repaired as it has a comparatively larger caliber (0.75mm) than the radial digital artery (RDA, 0.5mm). The anastomosis was initially successful without the need for vein graft, with clinically good distal perfusion and bleeding, however, this was short-lived as it thromboses after 10 minutes. Upon further exploration of the UDA distally and proximally, an area of lucency with hourglass deformity was found distal to the injury which indicates intimal damage.

a *b* *c*

Fig. 1. Urbaniak Class III (complete amputation) ring avulsion injury of the right thumb: *a* — Ryle's tube was cannulated through the flexor tendon sheath to guide the re-insertion of the FPL; *b* — amputated port of the right thumb (note the differing level of injury to skin, bone, tendon); *c* — skin along the amputation line is loosely closed to accommodate tissue edema without compressing the digital blood vessels. Skin allograft was applied as a temporary cover

As the intimal injury of the UDA was too distal with diminishing caliber size, the RDA was subsequently explored and anastomosed. A 10 mm gap was present at the site of injury, requiring the use of vein graft which was harvested from the volar aspect of the wrist, conveniently accessed via the same incision made to bank-in the proximal end of the avulsed FPL tendon. Two venous anastomoses were performed — one at the radial aspect of the thumb (next to the artery) and another at the dorsal aspect. Reperfusion of the amputated thumb achieved after 14 hours and 30 minutes following trauma. The thumb was allowed to warm up before the digital nerves were coapted. Skin allograft was applied over the area of the open wound as temporary coverage and to facilitate tension-free closure (Fig. 1, *c*).

Following surgery, the child was kept sedated and paralyzed for 48 hours. Continuous intravenous heparin infusion was commenced. The circulation of the replanted thumb was closely observed. The replanted thumb demonstrated good circulation until day 5 of surgery when it became clinically congested. Duration of continuous intravenous heparin infusion was extended further, regular pinprick to exsanguinate blood was performed, followed with a local application of heparin over the pinprick site. Wound along the amputation was managed with modern dressing and allowed to heal by secondary intention. The replanted thumb remained viable and the child was subsequently discharged.

Upon outpatient follow-up one-month post-trauma, the extensor policis longus tendon was noted to be exposed as a result of skin edge necrosis distal to the amputation line with an area of 2x1.5 cm. The child was subsequently brought to the operating theatre at which the first dorsal metacarpal artery flap (FDMA flap) was raised to cover the exposed tendon. Recovery was uneventful following the surgery (Fig. 2). At 2 months following trauma, the FPL tendon was transferred to the FDS of the ring finger with the aim to restore thumb flexion with the repair performed at Zone 5 (proximal to the transverse carpal ligament). Early active movement and rehabilitation were commenced following tendon transfer. He has good ROM at the CMCJ with good apposition however has stiffness over

a *b* *c*

Fig. 2. The design (*a*) of FDMA flap to provide soft-tissue cover to the exposed extensor tendon (1 month following trauma) (*b*); FTSG is utilized to cover the donor site defect (*c*)

Fig. 3. Functional outcome 10 months post surgery

the IPJ with delayed union of the fracture site. He is fully satisfied with the functional and esthetic outcome of the surgeries (Fig. 3).

Discussion

Despite the technical challenges and the potential risks, a little argument can be made against thumb replantation in a child. The importance of the function of the thumb was well described by John Napier by his statement "The hand without a thumb is at worst nothing but an animated spatula and at best a pair of forceps whose points don't meet properly" [4]. Replantation in young patients has a higher success rate, leveraging upon their enhanced wound healing capabilities [5]. Children can easily adapt to functional limitations, fully maximizing the remaining function following replantation.

As demonstrated by the case above, digit amputation by ring avulsion poses various challenges to successful replantation. Unlike guillotine type amputation, avulsion amputation presents with differing levels of injury to the bone, tendon, vessels, nerve, and skin. To achieve a good functional outcome, each of these structures must be repaired or reconstructed and require extensive surgical exploration and dissection beyond the initial wound.

Intimal separation often extends far beyond the blood vessel rupture point following avulsion injury[6]. Intimal separation may expose the highly thrombogenic tunica media and thus causes thrombosis following anastomosis. This was seen in our case when the initial anastomosis was unsuccessful. Despite considerable dissection of the vessel done initially, a section of intimal damage was missed as it occurs even further distal from the transected point. Therefore, to achieve good patency rate, there must be a thorough exploration and complete removal of the injured vessel, and at which the anastomosis is done away from the zone of injury. An interposition vein graft may be required to bridge the gap following removal of injured vessel, however, the vein graft by itself may contribute to thrombosis as it lacks elastic lamina that allows for expansion during systole and contraction during diastole which causes turbulent flow [6].

The usage of heparin has been revealed to decrease thrombosis rate in micro anastomosis [7]. While there is no consensus regarding the risk-benefit of continuous intravenous heparin infusion following digit replantation [8], it was commenced in our case in view of multiple risk factors that contribute to thrombosis. This, however, came at a price as the child developed multiple bleeding episodes through the wound requiring blood transfusion, which, in itself carries risks. No less than a day following discontinuation of continuous heparin infusion and normalization of the activated partial thromboplastin time (aPTT) at day 5 post replantation, the replanted thumb became clinically congested, suggesting of venous thrombosis. This underscores the role of continuous heparin infusion in a complex digit replantation in preventing thrombosis.

Late-onset venous congestion following replantation poses another dilemma for the microsurgeon. Surgical exploration and re-anastomosis may compromise the healing arterial anastomosis. Inflammation following prior surgery may not yet settle, presenting with fragile, leaky vessels which makes re-anastomosis even more challenging. While "arterial-only" replantation reportedly can lead to a successful replantation [9], means to provide temporary venous outflow must be made while effective peripheral circulation is

established. In our case, pinprick at regular intervals at the nailbed, followed by local application of heparin proved adequate in exsanguinating congested blood.

Post-operatively, a young child may become restless — being in an unfamiliar environment compounded by inherent fear towards healthcare staff. Despite the best effort for stabilization and protection, restlessness may compromise a newly replanted digit. Our patient was kept sedated and paralyzed for 48 hours following surgery, necessitating intensive care. Following extubation, the child heavily guards his right hand and becomes agitated whenever inspection is made to his replanted thumb even with the gentlest approach. We overcome this by constructing a heavy POP backslab with a protective hooded space for his right hand to protect against accidental trauma to the replanted thumb.

Secondary procedures commonly ensue following successful digit replantation, either to treat secondary defects or to allow the return of a function [10]. In our case, the child has undergone two procedures following replantation. The first was to provide tissue cover to the exposed extensor tendon, in which the surrounding wound was initially left to heal secondarily. The first dorsal metatarsal artery (FDMA) flap was utilized, giving a "like to like" tissue cover to the dorsal aspect of the amputation line. We then performed tendon transfer (FDS of the ring finger to FPL). One month following tendon transfer (3 months following trauma), the child demonstrated good thumb flexion with intensive physiotherapy.

Conclusion

The journey through replantation of an amputated digit following avulsion injury poses various challenges both to the microsurgeon and patient. The success of digit replantation is assessed by the return of function and not merely a viable replanted digit, hence multiple surgeries may be required to achieve a successful outcome.

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Ethical statement. Informed consent for the patient has been obtained.

Author contributions

M.I. Hamzan, M.J. Jeffrey — the primary author and was involved with writing, editing and submitting this work.

A.S. Halim, A.Z. Mat Saad — involved in the design, writing and editing, reviewing and approving the final version of the manuscript.

All authors made a significant contribution in the research and preparation of the article. Additionally, all the authors read and approved the final version before publication.

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