Nonarterialized Venous Replantation of Part of Amputated Thumb—A Case Report and Review of the Literature

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Abstract Since the first successful replantation of a human thumb reported by Komatsu and Tamai in 1968, thousands of severed digits and body parts have been successfully salvaged. Restoration of anatomic form and function are the goals of replantation after traumatic tissue amputation. Regardless of anatomic location, methods include microsurgical replantation and nonmicrosurgical replantation, such as composite graft techniques. Numerous techniques to maximize tissue survival after revascularization have been described, including “pocket procedures” to salvage composite grafts, interposition vein grafts, and medicinal leeches to name a few. Artery-to-venous anastomoses have been performed with successful “arterialization” of the distal venous system in fingertip replantation. Although there is documented survival of free venous cutaneous flaps, to our knowledge this is the first report of a replanted composite body part (bone, tendon, soft tissues, and skin) utilizing exclusively multiple, microvascular, nonarterialized venous–venous anastomoses. We present a patient with an isolated band saw fillet amputation to the back of the

thumb at the metacarpal–phalangeal joint region, resulting in a composite graft composed of bone, tendon, soft tissue, and skin. The hand wound provided no viable regional arterial inflow source, but there were multiple good caliber superficial veins present. The amputated tissues were replanted and revascularized by using only venous blood flow. The replanted part survival was 100% with excellent function of the digit. We conclude that a hand composite body part involving bone, tendon, soft tissues, and skin can survive replantation with a strict venous blood supply if sufficient good caliber, microvascular, venous–venous anastomoses are performed, granted that arterial inflow options are not available. This is an isolated case, yet introduces a new way of thinking regarding tissue replantation.

Keywords Nonarterialized venous replantation · Composite graft · Thumb amputation

Introduction

Replantation of fingertips or other amputated composite grafts is often difficult, because the vessel diameters are small or no suitable vessels can be found in the amputated part. Clinical cases have been reported in which arterial inflow through a proximal arterial-to-distal venous anastomosis has resulted in a successful outcome when no arterio-arterial anastomosis was possible [3, 15]. Matsuda et al. [9] noted a statistically significant correlation between the number of anastomosed arteries and veins and the survival rate in finger replantations. However, this review revealed that the survival rate was correlated more closely with the number of venous anastomoses than of arterial anastomoses. We describe a case where no suitable arterial inflow

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was regionally available for revascularization of an amputated part of a thumb.

Case Report

A 62-year-old diabetic male presented to our hospital on June 2, 2004, with an amputation to the proximal portion of his left thumb (Fig. 1). While handling an industrial band saw to prepare a 150-pound frozen Halibut, he filleted the metacarpal–phalangeal joint region of the dorsal aspect of the left thumb, resulting in an amputated composite body part composed of phalanx, metacarpal, extensor pollicis longus, extensor pollicis brevis, adherent soft tissues, and the overlying skin. By definition, regional tendons, nerves, and veins were divided into two locations. The cut was precise with very little surrounding tissue trauma. The remainder of the hand was nontraumatized. The amputated tissue was properly packaged during transport. Evaluation of the wound revealed no viable regional arterial source to or within the composite graft (Fig. 2), yet there were numerous good caliber (1.5 mm diameter) superficial veins present.

Under general anesthesia, the filleted bone portions were juxtaposed and secured with cerclage tension band wires (Fig. 3). The joint capsule and extensor tendons of the thumb were repaired at both their proximal and distal ends, using standard suture techniques. The dorsal cutaneous nerves were not repaired because of the risk of disturbing this robust dorsal venous system. Similarly, dissection searching for regional arterial sources was limited to prevent surrounding tissue damage and possible compromise to this venous system. Five microvascular venous–venous anastomoses were performed for graft vascularity. The perfusion was obtained with two inflow veins from the distal phalanx of the thumb. Three outflow veins were established to tributaries of the cephalic vein at the

Figure 1 Partial thumb amputation with filleted metacarpal, proximal phalanx, and division of extensor tendons to thumb in two locations.

Figure 2 Composite thumb graft with skin, tendon, vein, soft tissue, and bone.

“snuffbox” at the base of the thumb. Clinical evaluation of tissue perfusion was favorable with this venous blood flow. Operative time was 2 h (Fig. 4). A residual small open wound on the thenar eminence was necessary to avoid venous compression; this was repaired with a skin graft 3 days later. At the conclusion of the venous anastomoses, the color of the replanted part turned pink. From the second to the tenth day, a bluish color was noted with ensuing epidermolysis of the part. Reepithelialization was complete by 4 weeks after replantation. Hyperbaric oxygen therapy was offered but refused by the patient.

Tissue replant and skin graft survival was 100% with favorable function of the thumb (Fig. 5). The patient was able to return to work and perform industrial activities.

Discussion

Since the dawn of microvascular replantation of amputated parts [6], numerous methods have been reported to maximize the favorable outcome of the surgeon’s efforts. Arterio-arterial reconstruction should always be sought in clinical replantation. When unsuitable anatomy is available, successful tissue revascularization has been achieved by

Figure 3 Plain radiograph of left hand, demonstrating amputation and subsequent cerclage wires with maintained joint space and viable bone.

using interposition vein grafts, arteriovenous (AV) shunts [5, 12], composite grafting techniques, and “pocket procedures” to bury replanted deepithelialized tissues near vascularized subcutaneous tissues, subdermal tissues, or

Figure 4 Intraoperative photo of replantation.

Figure 5 Fully healed thumb with favorable function.

fascia [1, 7, 8]. The strategy is to provide and maintain sufficient oxygen tension and nutrients at the capillary level of the replanted tissues to deter cell death. Wolff et al. [13, 14] performed both animal model and clinical studies that evaluated the oxygen tension in venous skin flaps. To our knowledge, this is the first report of a composite tissue replant consisting of bone, tendon, soft tissues, and skin being revascularized exclusively using a venous blood supply to reconstruct a hand defect.

To avoid prolonged anesthesia in this 62-year-old diabetic patient, we decided against a time-consuming, complex vascular restructuring of the anatomic region to allow for arterial inflow and an AV fistula. Although arterial inflow is optimal and the first line of therapy, we opted to limit extensive dissection to minimize regional tissue trauma. The caliber (1.5 mm diameter) of the venous system on the dorsum of the thumb was excellent in this patient. After contemplation, we decided that good venous flow through these favorable veins may be sufficient to nourish the composite tissue, gleaned from our knowledge of venous-flow-through-flaps and Bier's Block anesthesia. For example, there is very little scientific evidence on how Bier's Block actually works, yet reliably, infusion of an anesthetic through the venous system of the upper extremity provides excellent pain control not only at skin, but also at soft tissue and bone levels. Thus, venous channels may exist to retrograde perfuse these structures and provide a passage for the infused anesthetic to reach nerve endings. In a similar fashion, the exact mechanism allowing tissue reperfusion and survival using the aforementioned replantation technique remains to be elucidated. Several theories exist. Investigators have studied the duration of venous channel development at the periphery of flaps using experimental models. A reported 3–5 days are necessary to establish inosculation [10, 11]. It is known that rich AV shunts exist in the human hand to control heat exchange. Blood flowing in from a vein may pass into arterioles through an existing

AV shunt and circulate through the artery and capillary, allowing metabolic exchange [4, 15]. Also, because the filleted bone portions were juxtaposed, blood flow may be established through the trabecular bone. Brooks et al. [2] has also expressed theories on the exact physiology of venous flow-through-flaps proposing retrograde flow from the veins through the nutrient capillary bed into arterioles, or bypass of flow through the capillary bed altogether, relying on antegrade flow through venous plexuses. Future experimentation is required to fully comprehend and verify these theories.

Restoration of anatomic form and function are the goals of replantation. The goal is to establish arterial inflow to the amputated part. We recognize that a hand composite body part involving bone, tendon, soft tissues, and skin can survive replantation with a strict venous, nonarterialized blood supply if sufficient microvascular, venous–venous anastomoses of favorable caliber are performed. This is a solitary case presentation, but it introduces a new way of thinking regarding tissue replantation. Further experimentation is necessary to fully elucidate the physiology and reproducibility of this technique. In this particular case, we were able to provide a superior result to this patient than could have been expected with other reconstruction techniques.

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