Hyperbaric Oxygen Therapy and Prostaglandin E1 on Composite Graft for Fingertip Amputation: Two Case Reports

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Abstract

Fingertip amputation is a common traumatic injury which can be treated with revascularization therapy or composite grafting. This article reports two case studies showing the successful management of fingertip amputation using hyperbaric oxygen therapy (HBOT) and prostaglandin E1 (PGE1) treatment after composite grafting, where revascularization was not possible. HBOT was used to promote angiogenesis, improve oxygen transfer, and accelerate wound healing. At the same time, PGE1 was administered to control inflammation, stimulate cell proliferation, and promote tissue repair. These case reports offer effective approaches to treating fingertip amputation. The treatment strategy used in this study can be expected to improve patient outcomes and quality of life.

Keywords: Skin transplantation; Hyperbaric oxygenation; Prostaglandin E; Wound healing; Case reports

Introduction

Fingertip amputation is an important form of hand trauma that has a profound effect on an individual's function and quality of life. Despite the advancement of surgical techniques, reconstruction of fingertip amputation remains a challenging task for surgeons because it is still difficult to produce favorable results.

Treatment options for optimal restoration of the amputated section include microvascular anastomosis or flap procedures such as V-Y advancement flaps. The goal of treating fingertip amputation is to preserve length and soft tissue coverage while producing satisfactory cosmetic and functional results. While successful cases of microvascular anastomosis have been reported, composite grafting often shows favorable results in pediatric patients with poor cut surface conditions or whose compliance to microvascular postoperative regimens would be difficult to guarantee. Composite grafting, which refers to the complex implantation of two or more tissues (e.g., skin, cartilage, or nail), is an alternative when microvascular anastomosis is not feasible [1]. However, composite grafts often fail to produce optimal results, and may lead to failure of re-vascularization and tissue necrosis, which results in negative functional and emotional consequences for patients.

In this article, as a means for improved outcomes, we performed simultaneous administration of hyperbaric oxygen therapy (HBOT) and prostaglandin E1 (PGE1) to enhance tissue oxygenation and resolve necrotic tissue. With the following two case studies, we aim to evaluate the efficacy of HBOT and PGE1 in improving outcomes after fingertip amputation and to provide insight into the potential of this combined approach.
treatment approach. This study was approved by the Institutional Review Board of Wonkwang University Hospital (IRB No. WKUH 2023-11-044). The patients provided written informed consent for the publication of this study and the use of their images.

**Case**

**Case 1: fingertip injury from pruning scissors**
A 48-year-old male with a history of hypertension and a 20-pack-year smoking history presented to the emergency room with an injury on the radial side of his left ring fingertip from pruning scissors. The fingertip was completely amputated in a radial oblique fashion, about 1.5×1 cm in size, including part of the nail (Fig. 1). Prophylactic tetanus vaccination was administered, and foreign bodies at the amputated margin were removed with thorough aseptic saline irrigation. A #6-0 Ethilon suture was used to perform composite grafting, and 10 μg/2 mL of Eglandin (alprostadil) was mixed into 100 cc of normal saline and injected once daily for 10 days. To prevent infection, Flumarin (second-generation cephalosporin, 1 g every 12 hours) and Gentamycin (aminoglycoside, 80 mg every 8 hours) were administered. An ointment (Fucidin, Dongwha Pharm) and foam (Medifoam, Mundipharma) dressing was applied twice daily, while capillary refill and venous congestion level were checked daily. On postoperative day (POD) 2, blackish necrotic tissue was present, with a negative capillary refill test (Fig. 2). Since the patient appeared distressed by the possibility of additional amputation surgery, the decision was made to administer HBOT to help preserve the finger shape, and 100% oxygen was applied for 128 minutes at a pressure of 2.4 ATA in a multi-person chamber twice daily for 10 days. The wound gradually improved (Fig. 3), and the patient was discharged on POD 10. On POD 28, the patient reported a perfect satisfaction survey score with recovery of normal skin color and improved sensation; the patient felt pain when his fingertip was pricked with a needle (Fig. 4), indicating a successful recovery.

**Case 2: finger bitten by a patient**
A 24-year-old nurse with no specific underlying diseases presented to the emergency room immediately after a patient had bitten off her left third fingertip. The fingertip was completely amputated and had an irregular cross-section due to crushing.

![Fig. 1. Preoperative images. (A) Amputated state. (B) Distal part.](image1)

![Fig. 2. Composite graft on postoperative day 2. (A) Dorsal side. (B) Volar side.](image2)

![Fig. 3. Composite graft on postoperative day 7. (A) Dorsal side. (B) Volar side.](image3)

![Fig. 4. Postoperative day 28 of the healed fingertip. (A) Dorsal side. (B) Volar side.](image4)
damage from the human bite; the amputated part was 1×1 cm in size with a complete nail (Fig. 5). Immediately after arriving at the emergency room, the amputated fingertip was aseptically irrigated with cold saline, and the finger stump wound was cleansed through massive room temperature saline irrigation. Irregular bone margins were debrided to prevent wound necrosis from bone infection, and a composite graft was performed. Eglandin (alprostadil, 10 μg/2 mL) was injected once daily and 1.2 g of Kmoxilin (amoxicillin and clavulanate) was administered over the course of eight hours. However, on the first day after surgery, the fingertip appeared pale, with inadequate blood flow (Fig. 6). Recognizing the importance of early intervention, we initiated HBOT on the second day. Over the following weeks, the wound showed steady improvement with normal nail growth (Fig. 7), and skin color also returning on day 28 (Fig. 8). Regular follow-up examinations revealed no complications 6 months post-injury, and the patient was able to resume her normal activities, indicating a successful outcome.

Discussion

The fingertip is hyper-sensitive and comprises various tissues, including skin, subcutaneous fat, and nail. Therefore, when trauma occurs in this area, hand surgeons must be very prudent regarding surgical methods for reconstructive treatment. Treatment is based on the size, location, and depth of the defect, and the condition of the nail. These factors also act to determine the potential for secondary intention healing, the length of time required for treatment, and recovery of protective sensation.

When fingertip amputation is limited to the skin, split- or full-thickness skin grafts can be primarily considered. However, distal fingertip amputation often damages not only the skin but also subcutaneous fat and the nail bed. In this case, covering the defect using a local flap, promoting revascularization through microsurgery, or applying a composite graft using the amputated part should be considered. Better prognosis can be expected by covering the exposed defect area using a local flap such as the V-Y advancement flap or visor flap; however, these ultimately cannot avoid shortening the length of the finger. Therefore, we attempted to restore the fingertip using the amputated part with defatting to achieve aesthetic satisfaction.

Microsurgical replantation through artery and vein anastomosis typically has better prognoses of sensation and function,
and the success rate is higher than that of composite grafting. However, this requires significant microsurgical skill due to the extremely thin vessel size (0.3–0.5 mm) of the distal fingertip, and also close monitoring even after surgery. In cases where the vessels are in poor condition (e.g., in crushing injuries) or the success rate is expected to be low (e.g., in pediatric cases), a composite graft can be considered. According to the Ishikawa classification, composite grafting is appropriate for damage from the mid-nail to the fingertip, in zone 1 [2,3]. This is a cost-effective and short procedure compared to microsurgery. However, the overall success rate of composite grafting is extremely low in adults; hence, it is mainly applied to children under 10 years of age. It also has the disadvantage of being extremely vulnerable to infection compared to local flaps, and the possibility of late complications, such as graft contraction, cannot be ruled out.

To overcome the aforementioned low success rate of composite grafts, we administered additional HBOT and PGE1 during the healing process. First, HBOT increases the success rate of composite grafting as it promotes the production of reactive oxygen species by increasing the oxygen concentration in cells, which enhances angiogenesis. It also has the advantage of controlling inflammatory responses and reducing swelling [4]. Therefore, starting on POD 2, we used a multi-person hyperbaric oxygen chamber (Interoccean) to provide 100% oxygen at 2.4 ATA (atmospheres absolute) for 128 minutes twice daily for 10 days. Second, PGE1 is effective in increasing tissue survival in ischemic limbs [5]. Subcutaneous injections for ischemic leg ulcers are more effective than intravenous administration; however, intravenous injection is usually administered instead, due to the inconvenience of subcutaneous injections and difficulty of determining injection site or depth [6]. PGE1 has pharmacokinetic characteristics that show a maximum concentration in plasma at 120 minutes after entering the body, after which it rapidly decreases, suggesting that continuous intravenous administration may have enhanced effects [7]. Accordingly, we mixed PGE1 with 100 cc of normal saline and injected it 20 cc/hr continuously and intravenously. As the effect of these two treatments applied simultaneously has been previously reported, we aimed to determine the effect on amputated fingertips [8].

When applying HBOT, side effects may occur, including ear barotrauma, sinusitis, pulmonary hypertension, or nervous system oxygen toxicity. Therefore, we carefully checked the patient’s history before treatment; in the first case, the patient had previously suffered from otitis media. Hence, daily close monitoring was performed in consultation with the otolaryngology department after HBOT. Fortunately, the patient’s eardrums showed no major abnormalities, and the patient felt no discomfort. Additionally, both patients complained of moderate angiodynia during PGE1 injections. This improved with more dilute concentrations of PGE1 and slower injection speeds. However, further research is required for continuous injections, in particular the dose-effect relationship and pain [9].

Few reports have reviewed the healing process of composite graft followed by HBOT and PGE1 for fingertip injuries. Although the two patients differed in terms of age, sex, and smoking history, both had manual occupations; hence, a complete restoration of the fingertip region was critical. This case study is significant in that functional and aesthetic recovery were achieved without microsurgery, and that it may provide additional options for future treatment of fingertip amputations. Consequently, when microanastomotic surgery is not feasible for optimizing cosmetic and functional outcomes, we advocate for two combined therapies: HBOT and PGE1, with the aim of enhancing the viability of composite grafts.

This study has several limitations. First, generalizing the effect of treatment is challenging because only two cases were studied. Second, HBOT was applied from POD 2 and did not completely cover the hyperacute healing period. Third, follow-up after 4 weeks was not conducted regularly. Furthermore, HBOT was applied to patients of a relatively young age. Further research is necessary to determine whether HBOT is suitable for patients with underlying diseases or smoking history. Therefore, comparing the benefits and drawbacks of other surgical methods is necessary in a wider variety of cases.

Conflict of interest

This work was supported by Wonkwang University in 2023. Young Cheon Na is an editorial board member of the journal but was not involved in the peer reviewer selection, evaluation, or decision process of this article. No other potential conflicts of interest relevant to this article were reported.

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