Pediatric thenar flaps: a modified design, case series and review of the literature☆☆☆

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Background: Fingertip injuries are extremely common in children, and severe trauma with pulp loss requires soft-tissue reconstruction to restore length, bulk, and sensibility. The thenar flap is a well-described technique but there are few reports of its use in pediatric patients.

Methods: Pediatric thenar flap reconstructions were retrospectively identified from October 2000 to October 2010 at a single institution.

Results: Sixteen pediatric patients (eleven male, five female) underwent thenar flap procedures. The average age was 10.8 years (1.1–17.8 years). The average defect size was 1.5 cm × 1.5 cm (1 cm²–2 cm²). Division and inset occurred on average 16 days later (12–24 days). Average follow-up was 6.8 months (4.1–9.6 months). The average total active range of motion (TAM) in flexion was 248° (235°–260°) [normal maximum: 260°]. All patients had 85° metacarpophalangeal joint (MCP) range of motion (ROM) [normal maximum: 85°]. The average proximal interphalangeal joint (PIP) ROM was 103° (95°–110°) [normal maximum: 110°] in flexion, and an average 60° distal interphalangeal (DIP) ROM (55°–65°) [normal maximum: 65°] in flexion. Objective sensibility in the flap was ascertained as an average static two-point discrimination of 7 mm (6 mm–10 mm) in 10 compliant patients and was grossly intact in all other patients. There were no complications.

Conclusions: The thenar flap is a safe and effective option for pediatric fingertip amputation injuries requiring soft-tissue reconstruction.

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Fingertip injuries are the most common hand injury in the pediatric population necessitating a visit to the emergency department [1]. The majority of these injuries can be treated conservatively, but often the injury is severe enough to warrant surgical treatment. Severe trauma with fingertip amputation requires soft-tissue reconstruction to restore length, bulk, and sensibility, especially in children to preserve long-term functionality. There are numerous possible treatment options including primary closure, healing by secondary intention, skin grafting, local tissue rearrangement, or free tissue transfer or perforator flaps [2–6], and each plan must be customized to the individual.

The thenar flap was first described by Gatewood in 1926 [7], and has since been well reported in the literature with several modifications for reconstructing adults injuries. However, there are few reports of its application for pediatric patients. Two-staged elective reconstructions have traditionally been avoided in children because of concerns over the morbidity associated with two surgical procedures and two anesthetics. Delayed flaps also require more care and attention to splinting, wound care, preventing flap avulsion, and wound healing complications. We report our experience with a modified thenar flap reconstruction in pediatric fingertip injuries in a series of sixteen patients. This is the largest case series of pediatric thenar flaps reported to our knowledge.

1. Materials and Methods

Institutional review board approval for review of all thenar flap reconstructions from October 2000 to October 2010 was obtained, and all pediatric fingertip reconstructions were retrospectively identified. Patients younger than 18 years of age were included and patients with incomplete data, concomitant injuries, and patients with previous history of hand injury or surgery were excluded. The history, operative course, outcomes, and any complications were reviewed.

1.1. Operative Technique

Indications for a thenar flap reconstruction at our institution include: a volar oblique injury with total or sub-total pulp loss involving the region from the level of the distal interphalangeal joint (DIP) to the distal tip, exposure of distal phalanx without bone loss and no tendon or neurovascular disruption. All operations were

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performed under general anesthesia with appropriate antibiotic prophylaxis and under sterile tourniquet. The fingertip injury was irrigated and debrided of any devitalized tissue and the donor site was inspected and measured. A template was designed by either flexing the finger defect onto the thenar eminence to make an imprint, or by cutting a template in a 1:1 ratio on sterile foil or paper (Fig. 1). Thenar flaps were designed as proximally-based flaps. The flap is placed on the glabrous skin of the thenar eminence with the proximal portion of the flap at the level of the most proximal aspect of the metacarpophalangeal joint (MCPJ) crease, and positioned with the MCPJ flexed to near 90° and the proximal interphalangeal joint (PIPJ) in limited flexion to prevent a possible future contracture. The flap was designed in the shape of a pentagon with the width of the flap equal to the circumferential arc of the fingertip defect rather than the straight-line distance between the defect skin edges. This width must compensate for the arc of fingertip tissue that is lost. It is dissected from distal to proximal, incorporating subcutaneous tissue and fascia (Fig. 2). Dissection proceeds in a subfascial plane to preserve vascularity of the flap. Care was taken to identify and avoid injury to the radial digital nerve to the thumb (Fig. 2). The flaps are designed with distal redundancy in anticipation that the most distal portion may not be sufficiently vascularized. The flaps are then loosely inset with the apex of the pentagon projecting beyond the fingertip defect margin to provide bulk for a rounded tip. The donor site was closed primarily in all cases in a tension-free manner. The distal and middle phalanges of the affected digit were placed in close approximation to the thumb proximal phalanx to make the affected digit and thumb a single unit and prevent motion or sheer of the flap (Fig. 3). The flap was then dressed with non-adherent Telfa (Covidien, Mansfield, MA) under the pedicle to prevent kinking. Additionally, the affected digit and thumb are secured together with Steri-Strips (3M-Nexcare, Two Harbors, MN) to prevent movement. A bulky plaster cast was then used in a dorsio-volar orientation to prevent any movement of the thumb and affected digit and wrapped in gauze and splinted. Specifically, the splint utilized is a wrap-around dorsal blocking splint that simulta-
The TAM is a measurement that comprises active range of motion in extension of the MCPJ, PIPJ and DIPJ and expresses them in a single value. The average static two-point discrimination was 7 mm (6 mm–10 mm) in the flap. Sensibility was grossly intact in the other six patients and all parents reported normal use of the finger. No flaps underwent partial or complete necrosis. There were no nail deformities and all patients had normal nail growth and fingertip contour (Fig. 5). Each patient/guardian was inquired about intolerance to cold temperatures and all subjects denied any cold intolerance. There were no donor site morbidities, and no postoperative fixed flexion interphalangeal joint contractures, wound infections or other complications. No patients required sensory reeducation or extension splinting.

3. Discussion

Fingertip injuries are extremely common in the pediatric population [8–10]. The majority of fingertip injuries are treated conservatively, but some may require reconstructive surgery. Severe fingertip injuries with significant pulp loss and exposed bone are difficult to treat and must have a reliable reconstructive option, especially in children. However, most studies for fingertip reconstruction are in the adult population and there is no consensus on management of pediatric patients.

Distal fingertip injuries in children are more common in boys, and right and left hand injuries occur at near equal frequencies despite the majority of the population being right-handed [11–14]. Our study was consistent with these reported findings. Radiographs should be obtained in all fingertip injuries, even though pediatric injuries do not commonly result in fracture [8]. None of the patients in our study had a fracture of the distal phalanx, while all had exposed bone without bone loss.

The goals of treatment for children with severe distal fingertip injuries include restoration or maximization of fingertip length, bulk and contour while preserving sensation, range of motion, and minimizing donor site morbidity. Depending on the extent of the injury, there are numerous treatment options available including healing by secondary intention, skin grafting, local tissue flaps, replantation and recently described microvascular free tissue transfer.

In the case of fingertip injuries where there is minimal soft-tissue loss and no exposed bone, healing by secondary intention or skin grafting is the most appropriate method of treatment [15]. While there is controversy over which method is best, many authors agree that defects < 1 cm² are probably best treated by conservative secondary intention healing [16,17]. However, in children the absolute size of the defect relative to the size of the finger must be considered. If it is felt that the defect is too large for secondary intention healing, a full-thickness skin graft is a viable management option. Full-thickness skin grafts are preferred instead of split-thickness skin grafts for fingertip pulp defects because they contract less, are more durable, and regain sensibility better than split-thickness grafts. An excellent donor site for these skin grafts is the hypothenar eminence [18].

Injuries with fingertip pulp loss and exposed bone necessitate more complex treatment options including local tissue flaps. Transverse or dorsal oblique amputations to the mid-nail level without substantial pulp loss may be closed with simple V-Y Table 1

<table>
<thead>
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<th>Characteristic</th>
<th>Total</th>
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<tbody>
<tr>
<td>Number of Patients</td>
<td>16</td>
</tr>
<tr>
<td>Females (%)</td>
<td>5 [31]</td>
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advancement flap. Use of this flap to cover inappropriately large defects can result in dysesthesia/hyperesthesia and therefore patient selection is imperative. While revision amputation with trimming of exposed bone and primary closure of the defect is an option in adults, in children this is less desirable because it is a priority to maintain finger length and bulk.

Other local flaps include the cross-finger flap, the homodigital island flap and the thenar flap [19–21]. Wang et al. recently described their experience with the homodigital island flap for fingertip reconstruction in children [21]. The authors utilized the flap in 11 digits in 10 patients. All patients in this study had a satisfactory outcome and maintained sensation without any complications. For certain patients with subtotal pulp soft tissue loss, the homodigital island flap is an excellent reconstructive option. But in children with more severe injuries, sufficient fingertip bulk may not be able to be restored with either a homodigital island flap or a cross-finger flap. Therefore, a more reliable and effective reconstructive option is needed for children with severe fingertip injuries involving total or sub-total pulp loss.

Replantation is a viable treatment option in children and successes have been reported by several authors [22–25]. Artery-only anastomosis for distal-tip amputations in children has been described with success including vessels as small as 0.3 mm [26]. However, establishing venous outflow by anticoagulation, leech therapy, or pulp incision drainage is not ideal in children. Furthermore, the majority of fingertip injuries in children are crush injuries and patients with extensive crush injuries are not ideal candidates for replantation.

When the fragment can be re-attached but microvascular anastomosis is not possible, some authors have suggested the use of a composite graft via the palmar-pocket. The palmar-pocket method involves de-epithelialization of the amputated part, suturing of the fragment into the defect, and placing the composite graft within a subcutaneous pocket for about two weeks prior to release [27,28]. Arata et al. reported their experience with the procedure in 10 children and found that all digits had acceptable return to function and cosmesis without any complications [27]. Complex injuries involving sub-total or total pulp loss and exposed bone often are
extensive and the amputated fragment either may be extensively crushed, avulsed, or may not be able to be found. In these cases, the thenar flap is a local, autogenous tissue source that provides substantial bulk for fingertip reconstruction with minimal donor-site morbidity.

In adults, the thenar flap of various modifications has long been considered a workhorse flap for fingertip reconstruction in injuries involving substantial pulp loss [7,29–33]. The many modifications of the flap include the pedicle source of the flap, location on the thenar eminence, perforator flaps, and also microvascular free tissue transfer of thenar flaps [32–34]. Although early studies indicated that the thenar flap has a high incidence of complications including flexion contractures and donor site morbidity, more recent studies have contradicted these concerns and our study confirms that the thenar flap is a highly safe procedure with minimal morbidity [30,35] and no flexion joint contractures.

In the early 1980’s, Melone, Beasley and Carstens presented their experience with 150 thenar flaps in patients of all ages [36]. While the majority of the patients were adult males, nine were children under the age of 10. These authors conclude that age of the patient is not a contraindication to the thenar flap and that it is an excellent reconstructive option. In this large series, none of the joint contractures (4% of patients) occurred in patients with isolated fingertip injuries, and all occurred in adult patients who had concomitant joint injury at the time of the initial trauma.

A 2004 case series of the thenar flap for reconstructing pediatric distal fingertip injuries by Fitoussi et al. examined twelve patients between the ages of 18 months to 11 years who had a distally-based thenar flap for fingertip reconstruction [35]. The authors reported no complications in their series and subjective patient satisfaction in eleven out of twelve patients. They also reported two cases of cold intolerance in their twelve patients. Our study further supports that the thenar flap can be used safely and effectively in children. Unlike Fitoussi et al., we utilize a proximally-based thenar flap and had no complications or cases of cold intolerance.

We report a case series of 16 consecutive pediatric patients who underwent thenar flap reconstructions at a single institution. All 16 patients had essentially complete return of function with excellent cosmetic results and there were no major or minor complications. There were no flexion contractures in our patients (all patients had full recovery of extension postoperatively), and only minimal stiffness in a few patients that responded fully to physiotherapy. There have been no reported postoperative flexion contractures in the literature of pediatric patients after thenar flaps. On the other hand, in the Melone series as above, 6 patients (4%) had postoperative flexion contractures and all of these patients were adults [36]. In general, children seem to be more amenable to short-term splinting with less risk of flexion contracture. For example, a 2009 study by Weber et al. reported a series of 33 pediatric patients after splinting for volar plate injuries and of these patients only one required physical therapy for joint stiffness and that patient regained full TAM [37]. Regardless, it is absolutely essential to avoid prolonged immobilization and to initiate early range of motion physiotherapy for successful outcomes and to avoid problematic contractures.

Fig. 5. Patient from Fig. 1, six month follow-up photos. (a) Dorsal view; (b) volar view; (c) close-up of left middle fingertip; (d) donor site. Black arrow denotes well-healed thenar eminence donor site.
The thenar flap is an ideal reconstructive option in a volar oblique injury with total or sub-total pulp loss involving the region from the level of the DIPJ to the distal tip, exposure of distal phalanx without bone loss and no tendon or neurovascular disruption. Advantages to using the thenar flap in children include recovery of bulk, contour and fingertip projection by using locally available autogenous tissue with little donor-site morbidity. A two-staged surgery with two anesthetic exposures is not always ideal in children, however, to achieve the appropriate reconstruction it may be necessary and parents must be properly informed and consented. In addition, postoperative care for the thenar skin bridge and immobilizing cast makes patient selection critical in pediatric patients.

Limitations of this study are the small size of the study and difficulty obtaining long-term follow-up. However, pediatric fingertip injuries severe enough to require operative reconstruction are rare, and this is the largest reported series of pediatric thenar flaps. The limited follow-up is thought to be partly due to the patient population of a city hospital, where financial and time constraints limit frequent follow-up; this phenomenon has been previously described in outpatient hand surgery in the postoperative period [38]. Noncompliance with follow-up may possibly indicate patient satisfaction and the perception that follow-up is unnecessary. Despite these limitations, we believe that the thenar flap is a safe and effective reconstructive option for pediatric patients. The thenar flap for fingertip reconstruction in children with severe fingertip injuries involving pulp loss is not contraindicated because of age, and can certainly be successful in the appropriate patients.

References