Microvascular management of ring avulsion injuries

Microsurgical revascularization has proved to be a useful method in managing the ring avulsion injury where both neurovascular bundles are damaged with only partial skin avulsion. Representative cases are used to illustrate guidelines for a practical classification for helping to decide the optimal method of treatment of acute ring avulsion injuries in light of digital revascularization techniques. Nine ring fingers were successfully revascularized of 24 acute ring avulsion injuries reviewed. Sensibility recovery was good and a functional range of motion obtained. No patient who has had his ring finger revascularized has requested its amputation because of appearance, painful neuromas, stiffness, or cold intolerance. Complete amputations, especially proximal to the superficialis insertion, and complete degloving injuries of the ring finger are usually best managed by surgical amputation of the digit.

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Although Gillies recommended a tubed pedicle for treatment of a “denuded finger” in 1940, avulsion injuries due to a ring were first specifically mentioned in the English orthopedic literature by Bunnell in 1948. Other authors discussed primary amputation, primary ray resection, or complicated resurfacing procedures. Some comment has been given concerning the microvascular treatment of a single amputated digit, but no one has published a useful guide to treatment incorporating revascularization concepts. All of these options have complications. The primary amputation involves complete loss of the finger, loss of symbolic position of the ring finger, possible painful neuromas, or loss of good pulp tissue. Primary ray resection is expedient, but involves the above-mentioned complications plus loss of palmar width. Long, complicated skin and neurovascular pedicle operations involve periods of immobilization with frequent occurrences of joint stiffness, infection, bulbous fingertips, and loss of sensibility. These potential complications can be avoided with successful microvascular reconstruction of a severely damaged ring finger.

Treatment guide

To be effective, a classification should be short, easy to remember, and practical. With microvascular techniques in mind, ring avulsion treatment can be separated into three classes.

Class I: Circulation adequate. Standard bone and soft tissue treatment is sufficient.

Class II: Circulation inadequate. Vessel repair preserves viability permitting immediate or delayed repair of other tissues.

Class III: Complete degloving or complete amputation. Judgment is essential because, although a complete amputation can be revascularized and viability restored, the potential function is limited. In degloving injuries, the potential for useful function exists, but revascularization is not easy or may not be possible.

Representative cases

Class I: Circulation adequate. W. W., a 33-year-old right-handed construction worker, caught the ring on his left ring finger on a falling cinder block, causing an almost circumferential laceration of the skin at the distal end of the proximal phalanx (Fig. 1). Damage involved the extensor tendon, flexor digitorum superficialis and profundus, and open dislocation of the middle joint with tearing of the volar plate from its insertion. The intact ulnar digital artery and nerve maintained good circulation and turgor to the distal end of the finger. Standard wound care was used involving extensor and flexor tendon repair, a volar plate reattachment, irrigation, and dressing of the wound with subsequent delayed skin closure. The patient achieved an essentially full painless range of motion (0° to 110° at the proximal interphalangeal joint), normal sensibility, and cold tolerance in the digit.

Class II: Circulation inadequate. J. B., a 24-year-old right-handed construction worker, fell 8 feet and caught his wedding ring on the scaffold, sustaining a complete circumferential degloving type injury extending to the base of the fingernail (Fig. 2). All tendons and bones were intact. The distal joint was dislocated, with rupture of the volar plate and collateral ligaments. Both neurovascular bundles and all dorsal veins were avulsed with the skin. There was inadequate perfusion of the distal digit as evidenced by no capillary refill,
Fig. 1. Class I type of ring injury in a 33-year-old construction worker. The skin injury was circumferential with laceration of the extensor tendon, flexor superficialis, and profundus and open dislocation of the proximal interphalangeal joint with injury to the volar plate. One intact neurovascular bundle maintained good circulation. Standard wound care, tendon, nerve, and volar plate repair, and delayed skin closure resulted in a good range of motion and sensibility return.

D. B., a 23-year-old Lumbee Indian male mechanic, sustained an amputation of the left ring finger after catching his ring on a truck (Fig. 3). The fracture involved the proximal interphalangeal joint and the skin was avulsed from the base of the proximal phalangeal level. Successful re plantation of the amputated finger involved proximal interphalangeal joint fusion and repair of the extensor tendon, both digital arteries, and nerves and five dorsal veins. He has recovered 12 mm of two-point discrimination and a full active range of motion of the metacarpophalangeal joint, but has rigid proximal and distal interphalangeal joints. He has never been quite satisfied with the appearance and function of the digit and was out of work for nearly 18 months.

Material

Between 1974 and 1979, 24 patients with an isolated ring avulsion type injury to the ring finger were seen in the Duke University Medical Center Orthopaedic Surgery Division (Table I). Seven patients who had the digit separated completely from the hand had an attempt at full replantation. Of these seven, five digits survived and two underwent delayed amputation. All three children in the series had complete amputations and all underwent replantation. Two of these replanted digits survived. Six patients were treated by amputation without an attempt at revascularization or replantation.

Sixteen ring fingers underwent revascularization or replantation and 14 survived. None of these patients has requested amputation of the revascularized digit. Although the finger may be shorter, all but one patient was pleased with the appearance.

Primary nerve repair was performed when feasible; however, if the injury was of the severely avulsing type, secondary repair or delayed nerve grafting was performed. None of the patients in the revascularized series has required reoperation for resection of a painful digital neuroma—a frustrating complication of amputations and ray resections.

Of nine successfully revascularized fingers available for follow-up, two-point discrimination averaged 10 mm (this includes only digits which had nerves severed and repaired) and total active motion 206°. Three completely replanted digits averaged 12 mm of two-point discrimination and total active motion of only 145°. Most of the restricted joint motion occurred at the proximal interphalangeal joint.

At the present time, our replantation team can replant a single digit in 3 hours or less of operating time. Since ring avulsion injuries frequently damage a long section of the vessels, vein grafting is frequently necessary and the procedure may be prolonged an hour or so. The hospital stay of a single replanted digit is usually 5 to 8 days. In our institution the cost of revascularizing a ring avulsion is comparable to the amount of financial compensation the patient (who has been injured on the job) would receive from the insurance carrier if the digit were amputated and not revascularized.

The patients in this study who had revascularization or replantation of digits have averaged 3 months out of work. The patients with complete amputations which were not replanted averaged more than 2 months out of work. Four patients required an additional operation each. One patient who had a complete amputation and
Ring avulsion injuries

Fig. 2. Class II type of ring injury in a 24-year-old construction worker. The tendons and bone were intact. The distal joint was dislocated and all neurovascular structures were severely severed (A). The digit appeared avascular with no capillary refill (B). Because of the degloving type of vascular damage (C), vein grafts were necessary to both digital arteries. Four veins and both nerves were repaired. Two-point discrimination of 9 mm and total active motion of 225° was achieved.

replantation has required four additional procedures. He would have benefited more from a primary amputation.

Discussion

Discrimination is necessary in the management of ring finger avulsion injuries. Significant digital vascular damage may occur in a ring injury even though the skin remains intact. The physician should be aware of this possibility and evaluate the blood flow of the injured digit by capillary refill, digital Allen test, and Doppler monitoring, or pulse volume recorder, if available.

If the skin has been opened by the ring avulsion injury, the vascular status of the digit must be determined. If the circulation, both arterial and venous, is adequate (Class I), basic wound care only is necessary. In the circumferential injury the skin should not be closed, but left open to prevent constriction and venous stasis which is likely from the posttraumatic edema which always occurs in this injury. During the first 4 or 5 days after the injury, frequent examination of the vascular status of the digit is mandatory.

The avulsing ring injury without complete amputation or degloving (Class II) usually damages the digital arteries, or veins, or both. The circulatory status of the injured digit can usually be determined by clinical ob-
Fig. 3. Class III type of injury with a complete amputation of the ring finger at the proximal interphalangeal joint level (A). The digit was successfully replanted (B), but the patient was out of work for 18 months and had a limited range of motion.

Table I. Ring finger avulsions

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<thead>
<tr>
<th>Amputation type</th>
<th>Class</th>
<th>Treatment</th>
<th>Survival</th>
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<tbody>
<tr>
<td>Incomplete (11)</td>
<td>I (2)</td>
<td>Debride only</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>II (9)</td>
<td>Revascularized</td>
<td>9</td>
</tr>
<tr>
<td>Complete (13)</td>
<td>III (7)</td>
<td>Replanted</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>III (6)</td>
<td>Amputated</td>
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</tr>
<tr>
<td>Total</td>
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<td></td>
<td>24</td>
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The preservation of the pulp turgor, color, and capillary refill. Again, monitoring devices help to evaluate the patency of the digital vessels. The most reliable method of determining the status of the digital vessels is to examine the injured digit under the operating microscope. Following axillary or brachial block and manipulation of the injured digit in preparation for the microsurgical examination, the surgeon may be pleasantly surprised to observe return of blood flow to a previously avascular digit. This spontaneous vascular recovery, which occurs not infrequently, indicates vascular spasm or partial arterial thrombosis which has been relieved by an improvement of the environment (pain relief, relaxation of the patient, warmer temperature, reduction of a fracture or dislocation, or relief of pressure). Careful microscopic examination determines which vessels and nerves can or should be repaired. Vein grafts or shifting of one reparable digital artery stump to the opposite side of the digit to attach it to a healthy distal stump are often needed. An attempt should be made to obtain two patent arteries and a minimum of three good veins. Because of the mechanism of injury, the nerves are often injured over a long area. However, with resection under the microscope, normal fascicles can usually be identified and end-to-end repair achieved. We have not performed primary nerve grafting as some microsurgeons have recommended, but have preferred to do secondary nerve grafting in the few digits in which direct repair was not feasible. On occasions, the arterial inflow may be adequate, and only the veins need to be reconstructed; conversely, only the arteries may need reconstruction if the dorsal skin is intact.

With the aid of microsurgery, the incomplete ring degloving or amputation with vascular deficit can now be successfully revascularized in almost all instances. The active range of motion, sensibility, strength, and appearance of the digit should approach normal most of the time.

The completely amputated or degloved ring finger (Class III) presents a more difficult problem. Achieving a viable digit by replantation is frequently possible, usually with the use of vein grafts. However, the ultimate success of the replanted ring finger involves much more than obtaining a viable digit. Is the grip improved? Can useful motion be obtained? Is sensibility near normal? Is the appearance acceptable? What is the
time lost from work? Can the patient return to his previous job? How many more operations will be necessary? What is the duration of the replantation surgery and the hospitalization? What is the chance of survival? Based on our experience with ring avulsion injuries, most of these questions can be answered preoperatively.

The decision of whether to replant the completely amputated or avulsed digit is difficult to resolve. Examination of the digital vessels of the degloved skin under the microscope may reveal that it is impossible to reestablish blood flow because of the irreversible damage of the distal vessels, and the choice to amputate becomes obvious. The degloved finger with intact tendons may fully flex and extend, but is still doomed without revascularization of the skin because of lack of satisfactory skin coverage and nutrition. Tubed pedicle coverage results in poor appearance, inadequate sensibility, and possibly joint stiffness.

In the Class III injury, if one or more joints are damaged and arthrodesis (particularly of the proximal interphalangeal joint) will result, replantation is less likely to be considered. If the patient is a laborer, we usually favor amputation, because if replantation is performed, the hospitalization will be about 1 week, the time lost from work will be 3 or 4 months, and subsequent reconstructive surgery is likely (tendon or nerve surgery). In addition, the grip obtained in replanting the completely amputated ring finger is about the same as the grip of a patient with an amputated ring finger.

Success in achieving viability is most difficult in the completely degloved digit (Fig. 4). In helping to make the decision, the patient should be informed of the likelihood of failure and the cost and length of the operation and hospitalization. In a young woman or child, we would be more likely to attempt restoration by revascularization of the degloved part, for if success occurs the appearance would be near normal and the motion and sensibility satisfactory. In the adult with a complete amputation of the ring finger proximal to the superficialis insertion, we recommend not attempting replantation.

**Conclusion**

Microsurgical revascularization has been particularly useful in salvaging incomplete ring avulsion amputations with insufficient vascular flow. Nine ring fingers injured by a ring avulsion have been successfully revascularized, and good sensibility and useful motion of the digits have been obtained. Six ring fingers were treated by amputation, either from the original injury or by the surgeon. Of seven completely amputated or de-
gloved ring fingers that were replanted, five survived, but had limited motion. Considerable judgment is involved when deciding whether to replant a completely amputated or degloved finger, but generally we favor revision of the amputation.

REFERENCES

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