Experiences of the High Energy Firearm Injuries at the Forearm and Hand

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Abstract

Objective: Weapon injuries have been increasing due to use of weapons widespread. This study aims to describe our experiences with high-velocity firearm injuries to the forearm and the hand.

Material and Methods: Seven patients who had high-velocity firearm injuries to the forearm and the hand were included in this study that was conducted between 2010 and 2015. All patients were male, and their mean age was 25 years (range, 21-33 years). On the average, patients were operated on within the first eight hours (range, 6-12 hours). There were two forearm injuries and five hand injuries. Revascularization could not be performed for two finger injuries, and the digits were amputated. Two forearm and three hand vascular injuries that needed microvascular anastomosis were operated on using interposition vein grafts. Vein grafts were obtained from saphenous veins in two patients and from dorsal foot veins in three patients.

Results: No microvascular complications were seen in the early or late follow-up periods. Phalanx fractures were seen in all hand injuries. On the average, patients were operated on three times (range: two-five) in the follow-up period.

Conclusion: In firearm injuries, microvascular repair should be performed out of injury zones; surgeons should not hesitate to use interpositional vein graft for microvascular repair, and physical rehabilitations of patients should be started in the early follow-up period.

Keywords: Firearm injuries, forearm, hand

INTRODUCTION

In an environment of rising violence, gunshot wounds are seen to inflict injuries that present with new characteristics that require complex treatment. Injuries caused by firearms can be affected by a number of variables such as the severity of the wound, the type of the weapon, the velocity and mass of the bullet, as well as its entrance range and angle. Injuries can be inflicted by low-velocity firearms (<2000 fps, mostly handguns) or high-velocity firearms (>2000 fps, rifles). Soft tissue and bony tissue damages are more common in wounds caused by high-velocity firearms. The mechanism of action of wounds caused by explosions is different from those caused by high-velocity firearms, and therefore excluded from this study. This study includes our experiences in treating hand and forearm injuries caused by high-velocity firearms.

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MATERIAL AND METHODS

This study includes seven patients who were injured by high-velocity firearms in the years from 2010 to 2015. Ethic committee approval was received for this retrospective study. All patients are male, with a mean age of 25 years (range: 21 to 33). Five patients were injured in the hand and two in the forearm. Tetanus prophylaxis was administered to all patients. On the average, vascular repair was performed within the eight hours after the injury (range: 6 to 12 hours). All of the finger injuries involved digital nerve injury accompanied by vascular injury, and digital nerve repair was carried out with an epineural microsurgery technique (Carl Zeiss Microscope, Germany). Arterial reconstruction in two forearm wounds (one ulnar artery and one radial artery), and arterial and vein reconstructions in three digital wounds were performed using interposition vein graft. Interposition vein grafts were obtained from saphenous veins in two patients, and from dorsal foot veins in three patients. Saphenous vein grafts were used for repairing the radial and ulnar wounds, and the vein grafts obtained from dorsal foot veins were used for repairing the vessels of the finger. The mean length of the interposition vein graft used in finger wounds was 3 cm (2 to 4 cm), and the mean length of those used in radial and ulnar arteries were five and seven cm respectively. In one forearm wound in which arterial reconstruction was performed, the radial sensory branch was repaired together with the radial artery. Cases with phalangeal fractures of the hand were treated by reducing the fractured bones to their anatomic positions and splinting with Kirschner’s wire. All patients were administered infection prophylaxis using first generation intravenous cephalosporin preoperatively and postoperatively (Sefozin 1 g [cefazolin sodium] Bilim İlaç). Patients who underwent vascular repair were given anticoagulation therapy with low molecular weight heparin (LMWH; Clexane [enoxaparin sodium] 0.4 ml Sanofi Aventis) by subcutaneous injections once a day for seven to ten days.

RESULTS

Two fingers in injuries that were evaluated as unsalvageable were amputated (Figures 1-3). In these cases where amputation was necessary, parts of the amputated material that were evaluated as viable were used as graft donor source. Shortness occurred in one of the salvaged fingers due to partial bone loss (Figures 4, 5). Complications such as infection and hematoma were not observed in the early postoperative period. Interposition vein graft donor sites recovered uneventfully during the follow-up period. In the follow-up period patients underwent an average of 3 (2 to 5) procedures to make up for partial tissue loss and to enhance functional gains. Patient compliance was observed at a very good level (Table). Physical therapy exercises were started in their respective early postoperative periods.

DISCUSSION

Firearm injuries are increasing in parallel with incidents of violence. Firearm injuries occur when a foreign material (bullet) hits a part of the human body at a high speed. Wounds caused by high-velocity firearms come forth as highly complex traumas influenced by the environmental conditions of the incident as well as the properties of the bullet. The aim of this study is not to examine the variants of weapons, bul-

![Figure 1. a, b. High-velocity firearm injury to the right hand.](image-url)
lets or of the environments, but to share our experiences in
the treatment of high-velocity firearm injuries in the forearm
and the hand regions.

It is important to separately evaluate high-velocity firearm
injuries to the extremities.\textsuperscript{4} Since the hand is a versatile or-
gan, the primary aim is to ensure optimal functionality as well
as vitality.\textsuperscript{5} It is therefore recommended to avoid aggressive
debridement when this procedure is necessary for treating
such injuries in the hand and the forearm.\textsuperscript{6,5} We, too, believe
that conservative, minimal, progressive surgical debridement
will be beneficial for optimally preserving the tissue in cases
which require debridement. In cases which the injured sec-
tion of the extremity is deemed impossible to salvage, we
believe it would be useful to spare any tissues from the am-
putated material, such as bone, tendon or skin, that are eval-
uated as reusable, and used for grafting in the other parts of
the extremity.

Figure 2. \textbf{a, b}. Material from amputation of a finger that was deemed unsuitable to revascularization was used as skin grafts for
the reconstruction of other injured areas.

Figure 3. \textbf{a-d}. (\textit{a, b, c, d}) Skin defect that occurred in the dorsal hand during the follow-up period was reconstructed with parti-
al-thickness skin graft.
The profiles of the patients—all male—in our study, support the findings reported in the literature, i.e. that firearm injuries are more common among young males. In the literature, it is seen that saphenous vein grafts are more preferred when interposition vein grafts are required in the reconstruction of vascular injuries. Saphenous vein grafting can be more suitable in the reconstruction of large-diameter vessels since it will help avoid disproportionate diameters in microvascular reconstruction. In our cases, we, too, preferred saphenous vein grafts in one forearm radial artery and one forearm ulnar artery injuries. Interpositional use of saphenous vein grafts in the finger region may cause disproportionate vessel diameters during microsurgery. Therefore, venous grafts taken from the dorsal side of the foot were used as interposition vein grafts in three of our cases. When vessel reconstruction is required in injuries caused by high-velocity firearms, reconstruction should be extended beyond the wound margins. We believe that extending vascular reconstruction beyond the margins of the wound zone without refraining from using interposition vein graft will increase the success of the treatment.

Since it has been demonstrated that there are no differences among prophylactic antibiotics in the treatments of firearm injuries to the extremities as long as good care is provided, we administered 1st generation cephalosporin to our patients.

**Figure 4.** Firearms injury and vascular wound on the second digit of the right hand.

**Figure 5.** a-d. (c) Arterial reconstruction was carried out using the interposition vein harvested from the right dorsal foot. (a,b,d) During the follow-up period, partial finger shortness occurred in the digit due to bone loss.
All cases that underwent vascular repair were given antithrombotic therapy using LMWH. Different views are reported in the literature on the use of various antithrombotic agents, whether combined or alone, and no consensus has been reached to date.\textsuperscript{10}

Once the vitality of the limb is ensured in injuries of the hand and the forearm, rehabilitation comes forth as a critical issue.\textsuperscript{2,6,8} Patients should be explained that the surgery is only the first step of a long-term therapy, and that they will need to receive good physiotherapy in the follow-up period. We believe that initiating physiotherapy exercises at the earliest possible time will increase functional gains.

**CONCLUSION**

We believe that, in hand and forearm injuries caused by high-velocity firearms, it will be beneficial to prefer minimal and progressive debridement; to refrain from primarily reconstructing the vessel in cases which vascular repair is required and to perform microvascular reconstruction using interposition vein graft and by extending beyond the margins of the wound; and to initiate a substantial physiotherapy program as early as possible.

**Ethics Committee Approval:** Ethics committee approval was received for this study from the ethics committee of Etimesgut State Hospital (30.11.2015/47-15).

**Informed Consent:** Written informed consent was obtained from patients who participated in this study.

**Peer-review:** Externally peer-reviewed.

**CONFLICT OF INTEREST:** No conflict of interest was declared by the author.

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**REFERENCES**