Animal Inflicted Maxillofacial Injuries: Treatment Modalities and Our Experience

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Abstract

Introduction Animal inflicted injuries to the face and neck are becoming much more common as people lavish affection on pets. Injuries caused by animal attacks to the face can cause complex injuries to soft and hard tissues, presented as perforations, lacerations, crushes, avulsion or fractures. An uncountable number of bacteria and virus can be found in such injuries, with a potential pathological effect to humans, regarding infections. Although the infection rate is low due to excellent blood supply to face, the injuries have disfiguring effect with possible psychological repercussion to the patients. The treatment of animal inflicted injuries must address the soft tissue defect, neurovascular injuries, and bone injuries as well as prevention of post treatment infection. Primary wound repair is the treatment of choice for most clinically uninfected bite wound where as delayed closure should be reserved for wounds at high risk of infection or already infected wounds and tissue defect may require local flap or micro-vascular re-implantations.

Material and Methods In this article, we have elicited up to date considerations regarding the management of animal inflicted injuries to the face based on literature search and exemplified by multiple case reports.

Conclusion For bite injuries on face, immediate primary wound repair after meticulous wound debridement and irrigation with sufficient volume added by antibiotic prophylaxis gives good cosmetic results with minimum risk of infection. Depending upon type of attack and age of victims, psychiatric or social counseling may also be required.

Keywords Animal inflicted injuries · Wound debridement · Primary repair · Rabies prophylaxis · Psychiatric consultation

Introduction

Animal inflicted maxillofacial injuries can result either from bites or from claws or from fall on ground or combinations of two or more. Approximately 4.5 million persons are bitten by animals each year; among them only 15 % seek treatment from health care providers [1]. Animal inflicted injuries to head and neck area are involved in almost 70 % in case of children as compared to only 5–15 % in case of adults [2]. The injuries can vary from simple abrasion of facial soft tissues to a complex soft and hard tissues injuries; such as perforations, lacerations, crushes, avulsion and fractures. Bite injuries are most commonly made by dogs (80–90 %). Wild animals like bear, tiger, racoon and others account for <6 % of maxillofacial injuries [3]; but the injuries can be more severe or even fatal. Management of facial bite wounds often presents special problems because on the one hand we have to provide the best aesthetic result which needs immediate primary closure and on the other hand there is risk of unforeseeable infections because of primary bacterial infections as well as the deadly viral infection i.e. rabies. Although many authors have found wound infections in <5 % of the cases [4, 5], others have reported an infection rate of 13–30 % [6, 7]. These differences have lead to varying therapeutic recommendations. Some authors have suggested that cleaning the wound with repeated saline irrigation and debridement without initial antibiotic therapy to be sufficient if there are no signs of infections at the time of treatment [8], while others have given antibiotics if there

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were high risks of infections as determined by the extent, especially the depth of wound [5–7]. In cases of large soft tissue defects, it may require extensive surgery such as local flaps and even microsurgical re-implantations to achieve optimal aesthetic results. Because of very few researches with successful microsurgical re-implantation reported in literature [9–11], some authors prefer primary reconstruction with local flaps [12]. Here we present the step by step treatments of animal inflicted injuries and their implementations in our cases.

Treatment Modalities

Initial Assessment

For all the cases of animal inflicted injuries, Advanced Trauma Life Support (ATLS) should be followed [13] with particular attention to cervical spine immobilization and neurological evaluation because a large animal can grasp the cranium with fangs and crush the cranium of children or shake them violently, thereby injuring the cervical spine [14]. Plain film or CT should be ordered, when appropriate. After initial assessment and stabilization, a comprehensive head to toe examination should be performed followed by past medical history including the status of the patients' tetanus vaccination. The time of bite, whether the animal was wild or domestic, whether the attack was provoked or unprovoked, and the number of bites and/or injuries should be noted [15]. The specialized structures of the face including the parotid ducts, facial nerve, and the nasolacrimal system, should be assessed individually. Care should be taken to evaluate the globe and an ophthalmologic consultation should be obtained, if indicated.

Tetanus Prophylaxis

All the bites are considered tetanus-prone wounds [16, 17]. Although the incidence of the tetanus is low; the high rate of mortality in case it occurs, makes the tetanus prophylaxis a priority. Tetanus prevention might not be necessary for a child victim that has followed an immunization calendar but an adult victim should be reinforced with vaccination if there is a 5-year gap since last dose [18]. If the history of tetanus immunization of the victim is unknown or if victim has received less than three doses of adsorbed tetanus toxoid, tetanus immunoglobulin should be administered [19].

Rabies Vaccine

The incidence of rabies has been declining steadily since 1950s [20]. This viral disease is most frequently carried in wild animals and domestic animals accounted for only

6.7 % of all the rabid animals reported in the United States during 2001. Although vaccination of domestic animals, vaccination programs targeting wildlife, and ongoing education programs have resulted in very low incidence of rabies in humans; post-exposure rabies prophylaxis should be considered for all the unprovoked dog and cat bites because of its high fatality rate [21, 22]. Biting animals with unknown or unclear history of vaccination should be observed for 10 days and rabies prophylaxis should be considered at the first clinical sign of disease [21, 22]. If animal has escaped, the decision to initiate rabies prophylaxis is based on local epidemiology of the rabies [21]. Rabies prophylaxis includes Rabies Immune Globin (RIG) and Rabies vaccine. The dose of RIG is 20 IU/kg (0.133 ml/kg), most of which should be injected in and around the wound and the remainder should be given IM [23]. Rabies vaccines should be administered intramuscularly in five doses on days 0, 3, 7, 14 and 28 after the attack [24]. RIG should not be administered if the patients have been previously vaccinated, but they should receive additional vaccine.

Antibiotic Prophylaxis

Antibiotic prophylaxis for animal bites continues to be debated, with few well-designed prospective studies available to shed any light on the controversy [25]. A review of randomized controlled trials comparing antibiotics with placebos in animal bites has failed to show the effectiveness of prophylactic antibiotics for dog and cat bites in anatomic areas other than the hand [25]. Although no single agent can eradicate all the microorganisms responsible for bite wound infections [26], several *in vitro* studies [27, 28] have suggested that amoxicillin–clavulanate is the gold standard for empirical antibiotic prophylaxis against dog, cat and human bites. In penicillin allergic patients, fluoroquinolones (moxifloxacin) alone or clindamycin in combination with either ciprofloxacin or trimethoprim–sulfamethoxazole have been recommended. Azithromycin is probably the most appropriate choice for penicillin-allergic pregnant women or children, for whom fluoroquinolones and sulfa compounds are contraindicated [29]. Antibiotic therapy for established infection is initially same as for prophylaxis; however definitive therapy is guided by culture and sensitivity [30]. If parental therapy is indicated in any patient, the treatment options include ampicillin–sulbactam, cefoxitin, and ticarcillin–clavulanate [26]. The duration of antibiotic prophylaxis is typically 3–5 days for soft tissue involvement and 10–14 days for bone involvement; and that for established bite wounds should be individualized based on site involved and response to treatment. Usually 7–14 days course is adequate for soft tissue infections; however a minimum of

3 weeks therapy is recommended for joint or bone infections [26].

Surgical Management of Bite Wounds

Because of rich blood supply, face and scalp are among the sites most resistant to posttraumatic infections [31] and facial bite wounds even when sutured primarily are associated with low infection rates, which in many studies are <6 % [32]. The primary focus in management of bite wounds is thorough wound cleansing by high-pressure, pulsed irrigation with copious amount of normal saline [33]. Pulsatile jet lavage at pressure of 50–70 psi has been shown to be highly effective in decreasing the bacterial load and removing the particulate matters [34]; however, it may cause soft tissue disruption [35]. Thus, use of pulsating jet device has been reserved for grossly soiled wounds [35]. Alternatively, time honored method of manual irrigation using 20–35 ml syringe with 18–20 gauge needle is widely recommended [21]. The volume of irrigant varies from 150 to 250 ml [32]; however, larger amount may be needed depending on level of contamination and size of wound [35]. For punctured wound, high pressure irrigation device with flexible catheter is used [17]. Although normal saline lacks bactericidal activity; it remains the preferred irrigant because it does not interfere with normal wound healing [32].

Immediate Primary Versus Delayed Primary Closure

Uncomplicated lacerations from bites on the face should be closed primarily within the first 24 h (the golden 24-h period) without fear of increased rate of infection [32, 36] because this gives the best cosmetic results; however, prior to wound repair, thorough exploration of wound depth is important in order to detect and subsequently repairing of any damage to facial nerve and parotid duct system [37]. Layered closure with minimum number of deep resorbable sutures is necessary to eliminate dead space [37]. Punctured wounds should be left open or converted to lacerations and then closed primarily. Wounds prone to infection such as those with late presentation can be repaired after 3–5 days of changing moist gauze dressing with equal cosmetic results [38]. Specialized techniques of wound pexis, skin graft, and local or regional flaps (Figs. 6c and 7b) should be considered when appropriate [39]. Avulsed tissue may require microvascular repair or tissue banking [40].

Local Flaps Used to Reconstruct Avulsion Defects

Local flap provides one-stage repair of avulsion defect with similar tissue that has its own vascular supply and is not

dependent on the perfusion of damaged tissue, as with free skin grafts. Facial flaps do best when based laterally or inferiorly with the incisions following normal skin folds and lines of expression. The basic skin flaps used on the face are advancement, rotational, transpositional and interpolated flaps.

Advancement Flap

Advancement flaps involve making two parallel incisions from the defect and undermining the tissue until the flap can be advanced into the defect under minimal tension. Classically, advancement flaps have a length-to-width ratio of 1:1 or 2:1 [41, 42]. Dog ears created at the base of the flap should be carefully excised. The advancement of two skin edges from a fusiform skin excision represents the simplest form of advancement flap design. The other advancement flap designs are as follows.

Single-Pedicle Advancement Flap With the single-pedicle advancement flap, a rectangle of skin is pulled forward on the basis of the elastic properties of the skin. Excision of deformities caused by flap design, such as Burrow's triangles, may facilitate movement of the flap and help to prevent the tissue from bunching and dog ears. It is unwise to move advancement flaps toward free margins, such as the lip and eyelid, because of the increased risk of ectropion and eclabium. Movement across or parallel to free margins is recommended [43, 44]. Single-pedicle advancement flaps work well in certain areas, such as the forehead, helical rim, upper and lower lips and medial cheek. Mucosal advancement flaps are also useful for vermilion reconstruction [45].

Bipedicle Advancement Flap With the bipedicle advancement flap, the same principles apply as for the single-pedicle advancement flap. An incision is made parallel to the defect and the flap is undermined and advanced. The equal and opposite motion of the two flaps minimizes the impact on the surrounding tissue. Because each flap covers only half of the defect, they are smaller and move less, which results in better relative blood flow and less tension on the closure [44, 45].

V-Y Advancement Flap With the V-Y advancement flap, an elliptical incision is planned over the defect using a 3:1 ratio, in which the length of the ellipse is three times the length of the defect. The advancing edges of the two flaps are trimmed and subcutaneous dissection started. Each V-shaped flap is undermined until a small central vertical base of tissue is formed. The two island flaps are advanced and approximated over the primary defect. The secondary defects are then closed primarily.

Rotational Flap

Rotational flaps use a semicircular flap to rotate tissue into a defect, with primary closure of the secondary defect. This flap requires careful planning to keep the incision from crossing too many natural skin folds. Classically, rotational flaps are designed to move along an arc of 30° or less with the radius approximately two to three times the diameter of the defect and the arc length approximately four to five times the width of the defect [42]. When possible, the flap should be designed so that it is inferiorly based, which promotes lymphatic drainage and reduces flap edema.

Transpositional Flap

Transpositional flaps involve swinging flaps into areas of defect over healthy tissue, with a secondary defect at the donor site that is closed primarily by undermining adjacent tissue or by coverage with a free skin graft. The length of the flap should not exceed three times the width, although the abundant vascularity of the head and neck often enables the development of flaps that exceed this 3:1 ratio. Like rotational flaps, these flaps tend to be pushed rather than pulled over the defect by forces created by closure of the secondary defect. They also tend to drape into place with very little tension. Careful planning is necessary because once flaps have been incised, they cannot be enlarged. The three classic transpositional flaps include the rhomboidal flap (Fig. 7b), bilobed flap, and Z-plasty [42].

Interpolated Flap

With the interpolated flap (Fig. 6c), the donor site is separated from the recipient site and the pedicle of the flap must pass over or under the tissue to reach the recipient area. A second surgical procedure is usually necessary to release and modify the flap. An advantage of the interpolated flap is the use of distant tissue with aesthetically pleasing characteristics, such as skin texture, thickness, and colour match. Interpolated flaps are often dependent on an axial blood supply. The most classic facial interpolated flap is the paramedian forehead flap, which receives blood supply from the supratrochlear artery. Another commonly used interpolated flap is nasolabial flap based on superior or inferior labial artery.

Here We Would Like to Share Our Experience with Management of Animal Inflicted Maxillofacial Injuries: Dog Bites Majority of dog bite patients were children of age <10 years (six out of nine) and all the patients were males. All the patients were stable at the time of presentation except for active bleeding in few cases which was controlled by pressure dressing. Neurological and cervical

spine examinations were within normal limits. The injuries encountered were lacerations with/without abrasion and in one case there was soft tissue defect. The sites involved were cheek, upper and lower lips, ala of nose and infra-orbital region. Status of facial nerve and parotid duct was within normal limit. Since all the patients were from rural area and the status of immunization was unclear, all the patients received tetanus toxoid vaccine. Since the patients were bitten by street dogs and the dogs were lost after the attack, all the patients received anti-rabies vaccine. Wounds were repaired by immediate primary closure after proper wound debridement and irrigation under GA for all the child patients (Fig. 1a, b) and one adult patient (Fig. 2a, b). However; before repair, wounds were irrigated with immunoglobulin and intralesional as well as intramuscular injections of immunoglobulin were also given. As the wounds were contaminated and infected at the time of presentation, delayed primary closure was done for two adult patients. After wound closure, all the patients received antibiotic prophylaxis with amoxicillin–clavulanate. None of the patients got infected postoperatively and the results were satisfactory for all the patients.

Bear Attack: Case 1 A 55 year old male patient reported to emergency OPD with history of bear attack while collecting fire wood in jungle. There was no history of loss of consciousness, vomiting and ENT bleeding. The patient was stable and neurological and cervical spine examinations were within normal limits. There was a complex avulsion injury involving left side of forehead and left temporal region, from where the laceration extended downward along an area about 1 cm lateral to lateral canthus reaching up to 1 cm lateral to left corner of mouth (Fig. 3a). There were no signs of diplopia and vision impairment but patient was unable to close his left eye. Under general anesthesia, after thorough irrigation with saline and wound debridement, layered primary repair of wound was done. Tetanus toxoid vaccine and antibiotic prophylaxis with amoxicillin–clavulanate were given. Post-operative recovery of the patient was uneventful; however the patient was unable to close his left eye (Fig. 3b) suggestive of paresis of facial nerve. When patient came after 1 week for follow up, he showed an altered behavior. So the patient was sent for psychiatric consultation but he did not return thereafter.

Case 2 A 35 year old male patient reported to emergency OPD with history of bear attack when he had gone to the jungle to graze his cattle. There was history of loss of consciousness for half an hour but no history of vomiting and ENT bleeding. On examination the patient was stable, neurological and cervical spine examinations were within normal limits. CT of the head was normal. There was a deep complex laceration involving forehead, anterior scalp

Fig. 1 **a** Child patient with dog bite showing lacerations involving *right* cheek and lateral orbital region. **b** One week post-operatively showing satisfactory wound healing

Fig. 2 **a** Adult patient with dog bite showing laceration of *right* side of *upper* lip. **b** One week post-operatively showing satisfactory wound healing with good cosmetic result

Fig. 3 **a** Complex laceration injury involving *left* half of forehead, *left* temporal region and cheek caused by bear attack. **b** Third day post-operatively, showing palsy of zygomatic branch of facial nerve with inability to close his *left* eye

with denudation of frontal bone. From right frontal region, the laceration extended downward up to about 1 cm lateral to right corner of mouth. There was complex laceration of right periorbital soft tissues. Similarly, on left side also the laceration extended downward up to upper eyelid (Fig. 4a). There was no sign of diplopia but there was blurring of vision in right eye. There was obvious fracture at left fronto–zygomatic (F–Z) region. Under general anesthesia, after thorough irrigation with saline and wound debridement, fracture was reduced, miniplate fixation at F–Z region carried out (Fig. 4b) and simultaneously primary wound repair was done. Tetanus toxoid vaccine and antibiotic prophylaxis with amoxicillin–clavulanate were given. Post-operative results were satisfactory (Fig. 4c).

Case 3 A 52 year old male patient reported to emergency OPD with history of bear attack. There was no history of loss of consciousness, vomiting and ENT bleeding. On examination the patient was stable, neurological and cervical spine examinations were within normal limits. There was a deep laceration starting from hairline of forehead which running obliquely reached up to lateral aspect of left

eye, from where the laceration run horizontally in infra-orbital region up to the medial canthus. From medial canthus the laceration passed downward along the lateral aspect of nose till the upper lip causing lip split (Fig. 5a). There was another laceration of about 5 cm on chin. There was a complex fracture with hollowing effect involving left maxilla and there was a fracture of left parasymphysis of mandible too. Under general anesthesia, after thorough irrigation with saline and debridement, the maxillary soft tissue repair was done in layers. For mandible, the fracture was reduced, titanium miniplate fixation was done in left parasymphysis region (Fig. 5b) and wound was closed primarily. Tetanus toxoid vaccine and antibiotic prophylaxis with amoxicillin–clavulanate were given. Post-operatively wound healing was uneventful. There were no signs of diplopia and blurring of vision; however there was deviation of upper lip towards right side suggestive of paresis of buccal branch of left facial nerve (Fig. 5c).

Tiger Attack A 32 year old male patient presented to dental OPD 10 days after the tiger attack with multiple sutured lacerated facial wounds and severely lacerated left

Fig. 4 **a** Bear attack causing complex laceration of scalp, forehead and right peri-orbital tissue with fracture in *left* F–Z region. **b** Performing ORIF with titanium miniplate at F–Z region. **c** Immediate post-operatively after primary repair of wounds

Fig. 5 **a** Bear attack causing complex laceration of *left* side of face. **b** Performing ORIF with titanium miniplate at *left* parasymphysis region of mandible. **c** One week post-operatively, showing palsy of buccal branch of facial nerve with deviation of *upper* lip to *right* side

Fig. 6 **a** Post operative case of tiger attack before secondary surgery with avulsed *left* globe and depressed fracture at *left* F–Z region. **b** Performing ORIF with transosseous wiring at *left* F–Z region. **c** Eyelid reconstruction with interpolated forehead flap

Fig. 7 **a** Case of horse bite showing tissue defect on *left* upper lip. **b** Wound repair by rhomboidal transpositional flap. **c** Satisfactory cosmetic result at third day post-operatively

globe (Fig. 6a). Sutures were removed on the first day of his visit and secondary surgery was planned for fracture reduction and eyelid reconstruction. During secondary surgery, F–Z fracture was reduced and fixation done by wiring (Fig. 6b) and with the help of ophthalmologist eyelid reconstruction was done using forehead interpolated flap (Fig. 6c). We had planned for ocular prosthesis after complete healing of wound but patient did not come for follow up.

Horse Bite A 52 year old male patient reported to emergency OPD with history of bite by his tamed male horse while feeding grass to it. There was no history of loss of consciousness, vomiting and ENT bleeding. The patient was stable and neurological and cervical spine examinations were within normal limits. There was a deep laceration involving left half of upper lip with loss of full thickness skin (size $4 \times 3 \text{ cm}^2$) as well as orbicularis oris muscle; however, the oral mucosa was intact (Fig. 7a). Tetanus toxoid vaccine was given and the patient was admitted in ward and antibiotic prophylaxis with amoxicillin–clavulanate was started. Despite antibiotic

prophylaxis, the wound got infected on third day. So wound repair was postponed for a week during which wound debridement and cleaning was done twice daily with sufficient amount of saline. After a week, the wound repair was done under general anesthesia by using rhomboidal transpositional flap (Fig. 7b) and post-operative wound healing was uneventful (Fig. 7c).

Discussion

The actual incidence of animal inflicted maxillofacial injuries in the eastern region of Nepal is unknown because we have treated only those patients who visited the only tertiary care center of eastern Nepal (BPKIHS) in last 2 years. Animal inflicted injuries are distinct in nature causing tearing, cutting, penetrating, crush injury and fracture. Mammalian bite injury can have distressing physical and psychological consequences [46]. Bite wounds have always been considered as complex injuries contaminated with unique polymicrobials. Facial bite

wounds generally display low infection rates, commonly attributed to the rich blood supply of the area. Significant delay beyond 6–12 h in seeking medical attention increases the likelihood of infection [47]. So while treating facial bite wounds it is important to avoid infection and to achieve aesthetically pleasing results. In literature, most authors considered intensive wound irrigation with adequate pressure as an absolute requirement; however, controversy continues on the timing of wound debridement and primary wound closure as well as antibiotic prophylaxis [47]. In our cases wound irrigation was done with 10 ml syringe with sufficient volume of saline and no specialized high pressure irrigating device was used. In few prospective studies, it was found that there was no significant reduction in infection rate in patients receiving antibiotic prophylaxis as compared to control group; however, antibiotic prophylaxis is recommended for special wound type such as deep or contaminated wound bites or hand bites and in diabetic patients [47]. Considering the late presentation to seek treatment and poor patient compliance regarding wound care, we gave antibiotic prophylaxis to all the patients with amoxicillin–clavulanic acid which is considered the gold standard antibiotic for animal bite wounds. Only one case (horse bite) got infected that was before wound repair. In case of facial wounds, primary tension free wound closure using subcutaneous sutures or local flap is recommended by some authors [12]; however, other authors do not recommend use of subcutaneous sutures to lower the risk of infections and in case of tissue defects [48], some authors prefer to do secondary reconstruction [12]. In most of our patients, the wound repair was done by immediate primary closure with sufficient number of subcutaneous sutures with good cosmetic results and without post-operative infections. Two cases of dog bites (both adults) were treated by delayed primary closure after antibiotic prophylaxis coverage for 1 week as the wounds were contaminated at the time of presentation. The only case of horse bite with tissue defect was managed by delayed reconstruction by local rhomboidal flap. Bite wounds are considered tetanus prone [16, 17]. So appropriate immunization should be administered if the patient has had fewer than three doses of tetanus toxoid in their lifetime or more than 5 years have passed since the last dose [18]. We gave tetanus prophylaxis to all the patients as almost all the patients were from rural places and immunization status was not clear. The range of dog bite injuries in our patients did not include fracture and neurovascular compromise; however, three out of four cases of wild animal attacks, presented with fractures (Figs. 4b, 5b and 6b) which were treated by open reduction and internal fixation and facial nerve palsy was also seen in them. Two patients (one horse bite and one bear attack) had severe psychological trauma. Maxillofacial surgery is a relatively new speciality in our

part of the world and it is still struggling to grow up. Our bitter experience with management of animal bite is that initially when we tried to manage the case of animal bite in maxillofacial regions by immediate primary closure, we had lots of objections from general surgeons as they prefer to manage the case by leaving the wound open to let it heal by secondary intension. But despite their objections, we managed the cases by primary repair and results were favourable with good cosmetic results and now they are positive towards our treatment protocol.

Conclusion

For bite injuries, immediate primary wound repair after meticulous wound debridement and irrigation with sufficient volume added by antibiotic prophylaxis gives good cosmetic results with minimum risk of infection. As compared to domesticated animals, wild animal attacks cause more severe injury ranging from complex lacerations to bony fractures and neurovascular injuries necessitating a team approach for management. Many of our cases were lost to follow-up and in few cases psychiatric problems were noted. So depending upon type of attack and age of victims, psychiatric or social counseling may be required.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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