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Le Fort Fractures: A Collective Review

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ABSTRACT

Le Fort fractures constitute a pattern of complex facial injury that occurs secondary to blunt facial trauma. The most common mechanisms of injury for these fractures, which are frequently associated with drug and alcohol use, include motor vehicle collisions, assault, and falls. A thorough search of the world's literature following PRISMA guidelines was conducted through PubMed and EBSCO databases. Search terms included "Le Fort fracture", "facial", "craniofacial", and "intracranial." Articles were selected based on relevance and examined regarding etiology, epidemiology, diagnosis, treatment, complications, and outcomes in adults. The analyzed studies were published between 1980 and 2016. Initial data search yielded 186 results. The search was narrowed to exclude articles lacking in specificity for Le Fort fractures. Fifty-one articles were selected, the majority of which were large case studies, and collectively reported that Le Fort fractures are most commonly due to high-velocity MVC and that the severity of fracture type sustained occurred with increasing frequency. It was also found that there is a general lack of published Level I, Level II, and Level III studies regarding Le Fort fracture management, surgical management, and outcomes. The limitation of this study, similar to all PRISMA-guided review articles, is the dependence on previously published research and availability of references as outlined in our methodology. While mortality rates for Le Fort fractures are low, these complex injuries seldom occur in isolation and are associated with other severe injuries to the head and neck. Quick and accurate diagnosis of Le Fort fractures and associated injuries is crucial to the successful management of blunt head trauma.

Keywords: Le Fort fracture; Facial trauma; Blunt head trauma.

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Introduction

Originally described by Rene Le Fort in 1901, Le Fort fractures are specific facial bone fracture patterns that occur in the setting of blunt facial trauma (most commonly involving motor vehicle collision, assault, or falls) [1,2]. All Le Fort fracture types involve the pterygoid processes of the sphenoid bones and therefore, disrupt the intrinsic buttress system to the midface-however further differentiation of Le Fort types I, II, and III depends on involvement of the maxillary, nasal, and zygomatic bones [3-5]. Though mortality rates are low, these fractures seldom occur in isolation and are often associated with serious injuries of the head and neck [6]. Thus, the ability to quickly recognize and diagnose Le Fort fractures is crucial for proper management of blunt-force facial trauma.

Methods

A comprehensive search of the world's literature was conducted through PubMed and Elton B. Stephens Co. (EBSCO) databases. Search terms included "facial injuries", "Le Fort", "facial", "craniofacial", and "intracranial" and the resultant articles were then categorized according to PRISMA guidelines. All studies in English were screened by title and abstract for relevance and sources discussing Le Fort fracture etiology, epidemiology, diagnosis, treatment, complications, and outcomes in adults were selected. Studies were excluded due to inadequate study size, inclusion of pediatric populations, or lack of relevance. The selections were then further limited to those published between 1980 and 2016 resulting in a narrowed reference list of 51 articles (Figure 1).

Results

An initial literature search for the term "facial injuries" returned 5,854 results. Next, a literature search containing "facial injuries" and "Le Fort" returned 491 results. Finally, a literature search containing "facial injuries" and "Le Fort" and "facial or craniofacial or intracranial" was done, yielding 176 results. Of these studies, 46 met inclusion criteria and 5 supplemental articles were identified outside of the search process, totaling 51 studies (Figure 1). The 51 sources consisted of one Level II study, thirty-six Level IV studies, and fourteen Level V articles (Tables 1 and 2). This review found Le Fort fracture types I, II, and III occurred in 16%, 19%, and 30% of facial trauma cases (Table 3) and the majority of these injuries were caused by high-velocity MVCs (Table 4).

Table 1. Levels of Evidence

Level of Evidence	Description
I	High-quality randomized controlled trials
II	Lesser-quality randomized controlled trials
III	Retrospective comparative study; case control study; systematic review
IV	Case series
V	Expert Opinion or case report

Discussion

Background

Le Fort fractures constitute a subset of injuries that result in discontinuity of the midface, a structure comprised of the maxilla, inferiolateral orbital rims, sphenoids, ethmoids, and zygomas. Fracture to these bones may result in disruption of the facial buttresses, which provide strength and rigidity to the facial skeleton. The facial skeleton contains four paired vertical buttresses: the lateral, medial, and posterior maxillary, and posterior vertical mandibular buttresses and four paired vertical

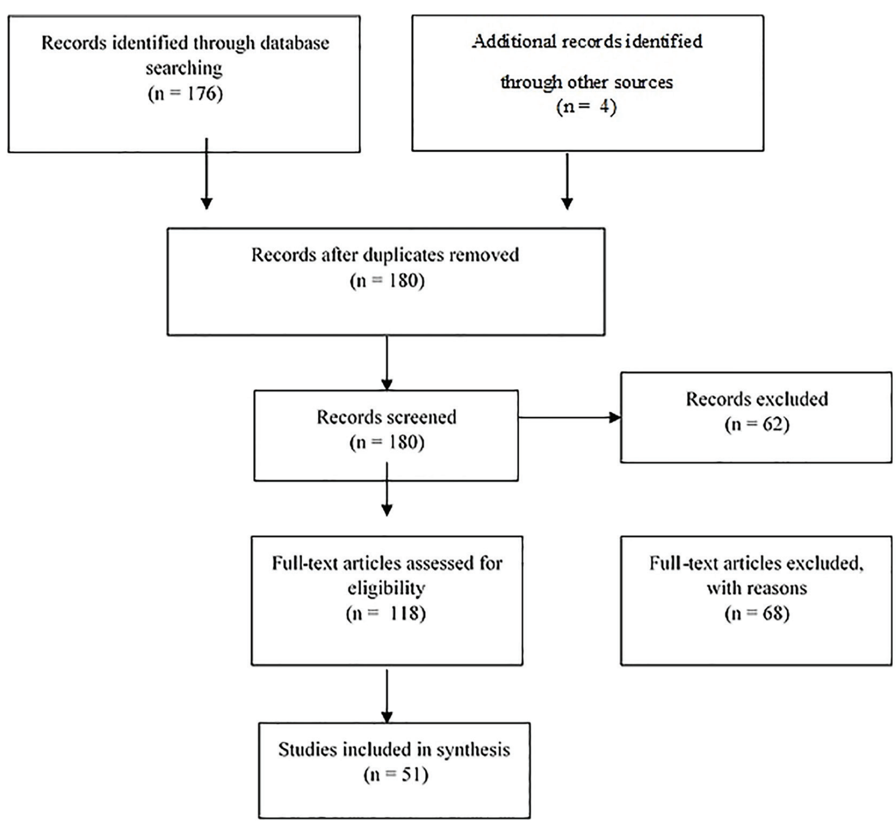

Figure 1. PRISMA-Based Approach

Table 2: Le Fort Fractures, 1980-2016, Level II and IV Evidence

Author	Year	N	Level of Evidence
Soong	2014	98	II
Steidler	1980	240	IV
Hendrickson	1998	376	IV
Garri	1999	194	IV
Gassner	1999	562	IV
Girotto	2001	334	IV
Jarupoonphol	2001	64	IV
Maladiere	2001	140	IV
Amin	2002	12	IV
Adebayo	2003	443	IV
Al Ahmed	2004	230	IV
Bagheri	2005	67	IV
Bell	2006	281	IV
Chen	2006	62	IV
Deogratius	2006	314	IV
Holmgren	2007	145	IV
Salonen	2007	155	IV
Lee, KH	2009	2581	IV
Lee, S	2009	121	IV
Guven	2010	16	IV
Salonen	2010	727	IV
Kummoona	2011	673	IV
Mohajerani	2011	243	IV
Zandi	2011	263	IV
Adeyemo	2012	156	IV
Ykeda	2012	277	IV
Hasler	2012	24000	IV
Bellamy	2013	3291	IV
Mundinger	2013	4398	IV
Beogo	2014	227	IV
Kaul	2014	542	IV
Patil	2014	50	IV
Petola	2014	374	IV
Rajkumar	2015	119	IV
Roumeliotis	2015	150	IV
Ruslin	2015	707	IV
Oliveira-Campos	2016	50	IV
McRae	2000	–	V
Tibesar	2001	1	V
Brown	2004	–	V
Mulholland	2005	–	V
Rhea	2005	–	V
Carinci	2008	117	V
Fraioli	2008	–	V
Lee, C	2008	–	V
Noffze	2011	–	V
Lo Casto	2012	–	V
Patel	2012	–	V
Winegar	2013	–	V
Devine	2013	1	V
Kunz	2014	–	V

Table 3. Le Fort Fracture Incidence

Year	Author	Specific to Le Fort FX	N total	LFI (%)	LF II (%)	LF III (%)
1980	Steidler	Yes	240	57 (23.8)	138 (57.5)	45 (18.8)
2001	Jarupoonphol	Yes	64	16 (25)	35 (54.7)	7 (10.9)
2003	Adebayo	No	443	26 (5.9)	60 (13.5)	8 (1.8)
2004	Al Ahmed	No	230	68 (29.4)	27 (10.7)	0
2005	Bagheri	Yes	67	22 (32.8)	22 (32.8)	23 (34.3)
2006	Deogratius	No	314	10 (3.2)	3 (0.9)	2 (0.6)
2010	Salonen	No	727	44 (6)	36 (5)	22 (3)
2011	Mohajerani	No	243	26 (10.7)	29 (11.9)	17 (7)
2012	Adeyemo	No	156	18 (11.5)	19 (12)	4 (2.5)
2013	Bellamy	Yes	3291	691 (21)[a]	780(23.7)[a]	1876 (57)[a]
2014	Kaul	No	542	47 (7.7)	78 (14.4)	18 (3.3)
2014	Peltola	No	374	38 (10.2)	39 (10.4)	36 (9.6)
2014	Soong	No	98	19 (19.4)[b]	6 (6.1)[b]	0[b]
2015	Roumeliotis	No	150	39 (26)	7 (4.7)	4 (2.7)
2016	Oliveira-Campos	No	50	11 (22)	26 (52)	3 (6)
TOTAL			6989	1132 (16.2)	1305 (18.7)	2065 (30)

[a]Some patients sustained different grade fractures on contralateral sides, thus the total percent of patients with Le Fort fractures is >100%. [b]These are the reported isolated Le Fort fractures, 10 patients had fractures involving multiple levels, including 4 LFIII fractures. Additional information was not available, so it was not included in analysis

Table 4. Le Fort Fracture Etiology and Concomitant Injuries, 1980-Present

Author	Year	Specific to Le Fort Fracture?	*N*	Most Common Age Group (years)	M:F Ratio	Most Common Etiology	Most Common Concomitant Injury
Steidler	1980	Yes	240	20-29 (39%)	4.9:1	MVA (80.8%)	Nasal Fracture (60.6%)
Girotto	2001	Yes	334		3:01	MVA (71.1%)	
Jarupoonphol	2001	Yes	664	21-30 (54.7%)	5.4:1	MVA (90.6%)	Mandible Fracture (28.1%)
Adebayo	2003	No	443	30	4.7:1	MVA (55.5%)	Craniocerebral (18%)
Al Ahmed	2004	No	230	20-29		MVA (75%)	
Bagheri	2005	Yes	67	LFI: 37.3 LFII: 42.5 LFIII: 39.8	LFI: 2.6:1 LFII: 6.3:1 LFIII: 10.5:1	MVA (58.2%)	
Deogratius	2006	No	314	20-29 (41.1%)	3:01	Assault (57.6%)	
Salonen	2010	No	727	37 (male); 41 (female)	4:01		
Mohajerani	2011	No	243	20-29 (39.5%)	4.29:1	MVA (65%)	Mandible Fracture (25.5%)
Adeyemo	2012	No	156	21-30 (36.5%)	3.7:1	MVA (93%)	
Ykeda	2012	No	277	20-39 (44%)	3:01	Assault (30.3%)	
Bellamy	2013	Yes	3291	39.6		MVA (40.8%)	
Kaul	2014	No	542	31-40 (36.3%)	3.7:1	MVA (56.8%)	Pelvis and Limb Fractures (64.0%)
Patil	2014	Yes	50	21-30 (54%)	11.5:1	MVA (78%)	
Roumeliotis	2015	No	150	40	11.5:1	Low-velocity Trauma [Fall <1 story or Assault] (63%)	
Oliveira-Campos	2016	No	50	21-30 (38%)	9:01	MVA (32%)	Zygoma Fracture (36.5%)

buttresses: the upper maxillary, lower transverse maxillary, upper mandibular, and lower transverse mandibular buttresses [7] (Figure 2). Disruption of these rigid structures may produce the midface instability and potential facial deformity associated with Le Fort fractures.

Le Fort I fractures are horizontal fractures of the anterior maxilla that occur above the palate and alveolus and extend through the lateral nasal wall and the pterygoid plates. These fractures result in mobility of the tooth-bearing maxilla and hard palate from the midface and are associated with malocclusion and dental fractures [7] (Figure 3).

Le Fort II fractures are pyramidal in shape and involve the zygomaticomaxillary suture, nasofrontal suture, pterygoid process of the sphenoid, and the frontal sinus. These fractures cause disruption of the medial, lateral, upper transverse, and posterior maxillary buttresses and produce discontinuity of the inferomedial orbital rims. Involvement of the orbit seen in such fractures may lead to the development of complications including extra-ocular muscle injury, orbital hematoma, globe rupture or impingement, and optic nerve damage. Furthermore, damage to the medial maxillary buttress has been associated with epistaxis, cerebral spinal fluid (CSF) rhinorrhea, lacrimal duct and sac injury, medial canthal tendon injury, and sinus drainage obstruction [4] (Figure 3).

Le Fort III fractures involve the nasal bones, medial, inferior, and lateral orbital walls, pterygoid processes, and zygomatic arches, which results in complete separation of the midface from the cranium. These fractures affect the medial maxillary, lateral maxillary, upper transverse maxillary, and posterior maxillary buttresses. Similar to Le Fort II fractures, they can be associated with orbital complications and CSF rhinorrhea [3-5,8] (Figure 3).

Though these fractures are defined by the collection of bones involved, Patil *et al*. found that only 24% of Le Fort fractures followed the classically described fracture patterns [9]. In this study, a majority of midfacial fractures (56%) partially resembled classic

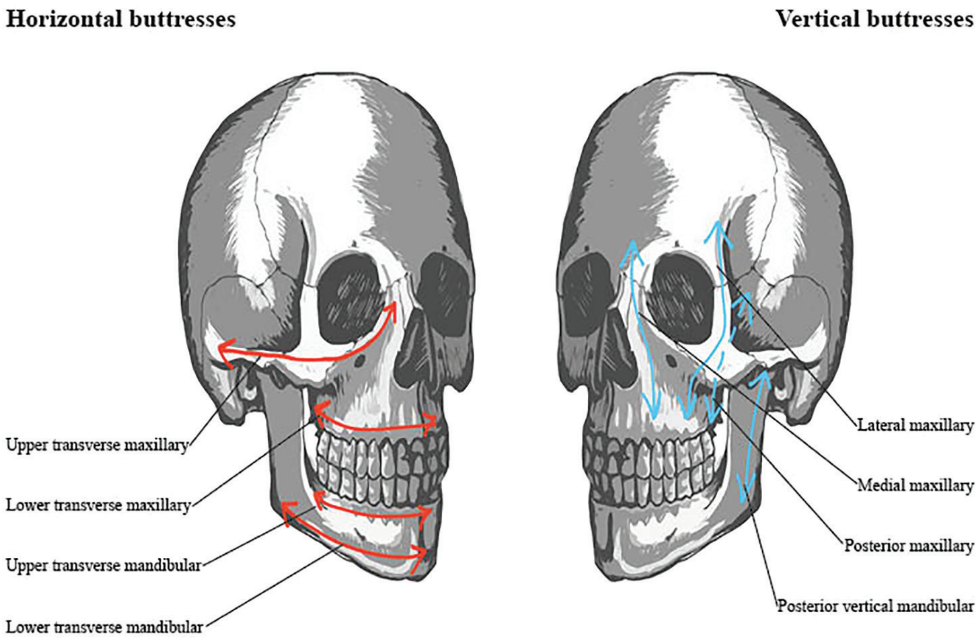

Figure 2. Vertical and Transverse Buttress Systems

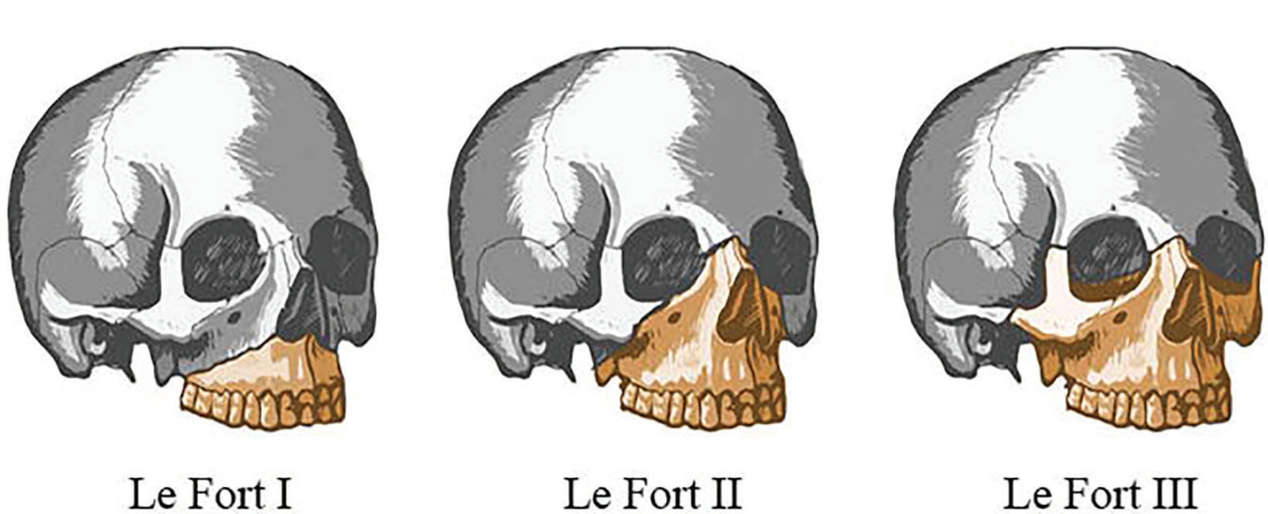

Figure 3. Le Fort Fracture Patterns

Le Fort fracture patterns but were associated with additional mid-face fractures including naso-orbito-ethmoid, palatal, zygomaticomaxillary, or dento-alveolar fractures [8]. An additional 20% of facial fractures were comminuted and did not follow Le Fort fracture lines at all [9]. As a majority of these fractures were caused by MVCs, the high forces involved may be responsible for this deviation from the classically described fracture patterns. This deviation indicates the need for a revised classification system that includes unilateral, comminuted, pan-facial fractures, and associated skull base and mixed dentition fractures [8].

In 2008, Carinci *et al*., [8] proposed a classification system that uses seven designated Midface Regional Units (MRU): a single nasal unit, and two paired alveolar, paranasal, and zygomatic units. Using this system, fractures are classified by the number of MRUs involved (Table 5). Le Fort I fractures are classified as F2 or F3 (two alveolar fractures), while Le Fort II and III fractures are categorized as F4. Le Fort II fractures contain five MRUs (two alveolar, two paranasal, and one nasal fracture) and Le Fort III fractures contain all seven MRUs. This classification system shows that there is a high correlation between the number of MRUs involved, the number of surgical interventions required, and the number of post-surgical complications developed [9].

Etiology

Trauma velocity has been associated with the type and severity of Le Fort fractures. Low-velocity trauma mechanisms, defined as a fall from standing height or blunt assault, were responsible for 56% of Le Fort I fractures. High-velocity trauma mechanisms, defined as falls from greater than one story or high-speed MVCs, were more closely associated with Le Fort II and III fractures. Higher grade Le Fort fractures were also associated with increased rates of concomitant head and neck injuries that most commonly involved skull fracture (40.7%), closed head injury (5.4%), and cervical spine injury (5.4%.) [10,11].

MVCs, assault, and falls were the most common etiologies of facial fractures [2,6,8,12-22] (Table 4). In developing countries, MVCs represented a higher proportion of fractures compared to all other causes [14]. Facial trauma that occurred secondary to assault commonly resulted in isolated low-energy nasal, orbital or ZMC fractures, however Le Fort I, II, and III fractures were identified in 6%, 5%, 3% of cases [23,24]. Falls resulting in facial trauma had a 43.9% incidence of Le Fort fractures, occurred from an average height of 7.3 meters, and were associated with extremity, head, or chest injuries 9.8% of the time [25-27]. Sports-related facial trauma had a greater frequency of Le Fort fractures in high-speed sports such as mountain-biking and skiing [28]. Specifically, Maladière *et al*. found that there was an increased incidence of Le Fort fractures in mountain bikers when compared to cyclists (15.2% vs. 3.7%), likely due to the high velocity and dangerous terrain associated with mountain biking compared to cycling. Conversely, lower velocity maxillofacial fractures typically occurred in the setting of contact sports such as soccer and rugby [28].

Drug and alcohol use has been documented in 28-45% of traumas that result in facial fracture and has been associated with more severe Le Fort fracture types [6,10,14,26,28]. One study found that positive screens for drug or alcohol use were present in 13.6%, 18.1%, and 52.1% of Le Fort I, II, and III fractures [6]. Another study identified positive screens for drug and alcohol in 52% of severe and/or comminuted Le Fort III fracture patients compared to 32% in Le Fort I and II fracture patients [13].

Diagnosis

Diagnosis of Le Fort fractures is made through physical examination and utilization of imaging. It is important to note that though physical examination findings such as raccoon eyes and midface mobility support the diagnosis of Le Fort fracture, they may not always be present and should not be overly relied on for diagnosis. Additionally, providers should avoid assuming bilateral symmetry or terminating the diagnostic process after identification of a single Le Fort fracture, as these classic fracture patterns are not always followed when injury is associated with high-velocity traumas [29].

Several radiologic features should trigger further evaluation for Le Fort fractures. The most important feature is the presence of a pterygoid fracture, which is found in all Le Fort fractures types. Other signs that should prompt the provider to investigate further for signs of Le Fort fracture include fractures of the lateral nasal wall, inferior orbital rim, lateral orbital wall, and the zygomatic arch [4].

Paranasal sinus effusions may be a useful indicator to determine whether or not a Le Fort fracture is present. In patients with facial trauma secondary to MVCs, a clear sinus sign (CSS) was associated with a

Table 5. Midface Regional Unit Classification System

Fracture	Description/ Midface Regional Units Involved	Corresponding Le Fort
F in situ	Fracture without fragment mobility	--
F1	1	--
F2	2	LeFort I
F3	3	LeFort I
F4	≥4	LeFort II and LeFort III

lack of fracture in 73%. Though the lack of paranasal sinus effusion does not rule out a midfacial fracture (sensitivity of 76.7%, specificity of 73.2%), Le Fort I, II, and III fractures were associated with paranasal sinus effusions in 100% of cases [25].

When visualizing Le Fort fractures, 2-D CT imaging is preferable to 3-D CT because it provides increased detail of fracture lines and associated soft tissue injuries [8]. However, 3-D CT is capable of identifying Le Fort fractures that are not obviously be seen on single 2-D cuts and may be helpful for surgical planning [10]. Multidetector CT (MDCT) is considered the imaging modality of choice because it produces high-resolution images and also allows for 3-D rendering. This facilitates identification of small fracture lines and differentiation of soft tissue and bone injury [25].

Management

Hospitalization was required for 84.5% of maxillofacial fracture patients [2]. The percentages of Le Fort I, II, and III fracture patients taken directly to the OR were 9.1%, 27.3%, and 26.1%, the average hospital length of stay for each patient was nine days, and each patient underwent an average of 1.7 operations [6].

Tracheostomy is an effective and safe way of securing airway management in the setting of severe facial trauma. One study found that tracheostomy was required in 22.4% of all Le Fort fracture patients and 43.5% of Le Fort III fracture patients [11]. The need for tracheostomy has been associated with poorer outcomes as the mortality rate for patients that did not require tracheostomy was 0%, while the mortality rate for those requiring tracheostomy was 7.2% [30]. Tracheostomy can often be avoided through utilization of fiber optic intubation techniques. Contraindications to endotracheal intubation include concomitant cervical spine injury or blast injuries affecting the face [31]. Retromolar intubation, orotracheal intubation secured in the retromolar space, allows for intraoperative mandibulomaxillary fixation and dental occlusion [26]. Submental intubation allows for unimpeded access of both the midface and the oral cavity [32]. Nasotracheal intubation in the setting of facial fracture is contraindicated as it can result in sinus infection, mediastinal emphysema, and most importantly, accidental intracranial intubation [26].

The goals for surgical management of Le Fort fractures include restoration of facial projection, height, and proper occlusion [4,31]. Preservation of midface structure is dependent on vertical buttress repair and restoration of midface aesthetics is achieved through repair of horizontal buttresses. Surgical repair traditionally follows the sequence of arch bar placement, fracture exposure, fracture reduction, malocclusion repair, plate fixation, and soft tissue repair [31]. This review found that Le Fort fractures required open reduction and internal fixation in 60% of cases, 30% of cases were managed conservatively, and the remaining 10% of cases required no treatment. Open fixation for Le Fort fractures at the zygomatic buttress, zygomaticomaxillary suture, and the frontozygomatic suture provides stable fixation and sufficient anatomic repositioning when indicated [22]. Le Fort fractures are frequently accompanied by fractures of the hard palate, dentoalveolar unit, and the mandible. This creates another set of challenges when attempting repair, as normal occlusion must be restored before the upper midface can be anchored to the maxilla. Furthermore, if there are concomitant zygomaticomaxillary complex, naso-orbito-ethmoid, or frontal sinus fractures, reconstruction of the frontal bar should be completed before resuspension of the midface takes place [4].

Upon review of the literature, most Le Fort I fractures were accessed surgically through a gingivo-buccal sulcus approach, while Le Fort II and III fractures often required additional subciliary or transconjunctival approaches [4]. A coronal approach offers wide exposure of the zygomatic arch in Le Fort II and III fractures, but can result in complications secondary to the dissection of neurovascular structures [22].

Minimally invasive surgical approaches provide an alternate method for surgical management of Le Fort fracture types II and III as they can be accessed via lateral eyebrow, intraoral vestibular, and subciliary approaches. All 10 patients with Le Fort fractures treated by this approach in a 2010 study experienced effective aesthetic results-no complications were observed [33]. Endoscopic zygomatic arch repair allows for dissection of the deep temporal fascia to protect the facial nerves. An endoscopic approach is not indicated if concomitant fractures necessitate raising a coronal flap for repair [34]. Minimally invasive approaches require increased operative time, specific training, and specialized equipment, but the potential to conserve facial neurovasculature is worth considering when managing Le Fort fractures [34].

Surgeon preference for the different plating systems varies, but generally 1.5-2.0 mm plates are adequate for fixation of the buttresses. Smaller plates may be used at the infraorbital rim, nasal root, frontozygomatic region, and zygomatic arch where less strength is needed and bone grafts may be used to bridge bony defects present in the buttresses. Management of fractures involving the hard palate has traditionally been accomplished with a palatal splint and arch bars, however Hendrickson states that rigid internal fixation may eliminate the need for palatal splinting and provide greater stability and accuracy for alignment [31,35].

Permanent rigid fixation has been implicated in cases of poor skeletal development. Up to 12% of titanium implants used for facial fractures require removal, generally due to palpable hardware, pain, plate or screw loosening or migration, infection, dehiscence, or thermal sensitivity. Biodegradable hardware is an alternative that provides sufficient stability to facilitate fracture healing, yet reabsorbs quickly enough to prevent a foreign body reaction. An additional advantage of biodegradable hardware is that is does not require removal if it becomes loose [36].

Other less common surgical techniques, including screw-wire osteotraction, crewe halo and box frame techniques, and wire fixation, were noted in our review of the literature. Screw-wire osteotraction (SWOT) is traditionally used in treatment of lower facial fractures, however it has been successfully applied to Le Fort injuries [37]. Crewe halo frame and box frame techniques have also been utilized to allow for triple rigid fixation for Le Fort II or III fractures without the need for incisions [38]. Wire fixation is also a promising alternative in developing countries where hardware can be prohibitively expensive [11].

In a randomized controlled trial, there was no significant difference in rate of infection between patients treated with 24 hours of post-operative antibiotics and those treated with 5 days of post-operative antibiotics [39]. Post-operative infections were detected in 4% of all zygoma and Le Fort fracture patients, with an equal number of infections occurring in both the one-day and five-day groups. All Le Fort fracture infections were associated with Le Fort I fractures treated by open reduction internal fixation (ORIF) through an intraoral approach. Factors such as body mass index (BMI), implant type, presence of multiple fractures, and smoking history had no impact on the rates of post-operative infection [39].

Concomitant Injuries

Patients with facial fractures should be evaluated for potential cervical spine and head injuries, especially when the injury has been sustained from a high velocity mechanism [40]. Le Fort fractures, specifically, have been associated with spinal fracture or dislocation (1.4%) and cervical cord injury (1%) [40]. Higher grade Le Fort fractures (types II and III) have been associated with a 2.88-fold and 2.54-fold increased risk of concomitant intracranial injuries, and of facial fracture patients requiring neurosurgical intervention, 70% had sustained Le Fort III fractures [10,11,21].

Ocular injuries including periorbital edema, subconjunctival ecchymosis, chemosis, diplopia, retrobulbar hemorrhage, optic nerve compression, traumatic mydriasis, and retinal detachment have been associated with 8.3% and 6.7% of Le Fort II and III fracture cases [41]. Of the ocular injuries associated with midface fractures, 4.5% required ophthalmologic surgical intervention for either lens dislocation or ruptured globe repair. Retinal detachment leading to blindness was present in 0.84% of these patients [42]. Because of the potential for ocular injury, a thorough ocular examination is necessary when evaluating a patient with midface fractures [42].

Dental injuries are associated with Le Fort fractures at higher rates than when compared to all facial fractures (47.7% vs. 23.2%.) [43]. This is likely attributed to the fact that the zygomatic complex is the facial bone most susceptible to fracture, yet requires bigger insult (due to its location) for dental injury to be involved. Blunt facial trauma has been associated with internal carotid injuries in 1.2% of cases, and specifically internal carotid artery injuries were found in 6.9%, 5.6%, and 3.0% of Le Fort I, II, and III fracture patients [44]. The Eastern Association for the Surgery of Trauma (EAST) recommends screening for internal carotid injury in asymptomatic patients with significant blunt traumatic head injuries including Le Fort II and III fracture patients [44].

Outcomes

Mortality rates of facial trauma patients depend on the mechanism of injury, location and severity of injury, and presence of associated injuries. Complex facial fractures, including Le Fort fractures, had a mortality rate of 11.6%, compared to 5.1% seen in simple midface fractures. Le Fort I, II, and III fractures had mortality rates of 0%, 4.5%, and 8.7%, respectively and Le Fort II fractures were associated with a 1.94-fold increased mortality risk when compared to simple facial fractures [21]. Le Fort fractures are associated with significant morbidity, including the development of visual problems (47%), diplopia (21%), epiphora (37%), difficulty with breathing (31%), and difficulty with mastication (40%) [13]. Patients with severe or comminuted Le Fort fractures have been reported to have higher levels of injury-related disability [13]. Fewer patients with a Le Fort III or comminuted fracture were able to return to work compared with those that had sustained Le Fort I or II (58% vs. 70%.) [13]. Satisfactory outcomes with regards to function and aesthetics were achieved in 89.1% of patients, while long term infection, temporary temporomandibular joint stiffness, or facial deformity were seen in 10.9% of patients [14].

Conclusion

Le Fort fractures are specific patterns of facial bone fractures that develop secondary to blunt facial trauma. While mortality rates due to Le Fort fractures themselves are low, these injuries rarely occur in isolation and are frequently associated with other severe injuries to the head and neck. The ability to quickly and accurately diagnose Le Fort fractures is crucial to the successful management of blunt facial trauma patients. Our review found that there is a lack of published data regarding Le Fort fracture management, especially reporting on the usage of minimally invasive surgical techniques and long term outcomes. Further research is needed to determine the optimal management plans for these patients.

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Compliance with Ethical Standards

All authors state clearly that we have nothing to disclose regarding potential conflicts of interest. This collective review study did not directly involve Human Participants and/or Animals. As such, informed consent was not required. This article does not contain any studies with human participants or animals performed by any of the authors. External sources of funding were not used in either the preparation or submission of this manuscript.

Conflicts of Interest: None declared.

References

1. Noffze MJ, Tubbs RS. Rene le fort 1869-1951. *Clin Anat*. 2011;**24**(3):278-81.
2. Kaul RP, Sagar S, Singhal M, Kumar A, Jaipuria J, Misra M. Burden of maxillofacial trauma at level 1 trauma center. *Craniomaxillofac Trauma Reconstr*. 2014;**7**(2):126-30.
3. Kunz C, Audige L, Cornelius CP, Buitrago-Tellez CH, Frodel J, Rudderman R, et al. The comprehensive AOCMF classification system: Midface fractures - level 2 tutorial. *Craniomaxillofac Trauma Reconstr*. 2014;**7**(Suppl 1):S059-67.
4. Fraioli RE, Branstetter BF, Deleyiannis FW. Facial fractures: Beyond le fort. *Otolaryngol Clin North Am*. 2008;41(1):51-76, vi.
5. Patel R, Reid RR, Poon CS. Multidetector computed tomography of maxillofacial fractures: The key to high-impact radiological reporting. *Semin Ultrasound CT MR*. 2012;**33**(5):410-17.
6. Bagheri SC, Holmgren E, Kademani D, Hommer L, Bell RB, Potter BE, et al. Comparison of the severity of bilateral le fort injuries in isolated midface trauma. *J Oral Maxillofac Surg*. 2005;**63**(8):1123-9.
7. Brown D, Borschel G. Michigan manual of plastic surgery. Philadelphia: Lippincott Williams and Wilkins; 2004.
8. Carinci F, Zollino I, Arduin L, Brunelli G, Pagliaro F, Cenzi R. Midfacial fractures: A scoring method and validation on 117 patients. *Eur J Trauma Emerg Surg*. 2008;**34**(4):385-90.
9. Patil RS, Kale TP, Kotrashetti SM, Baliga SD, Prabhu N, Issrani R. Assessment of changing patterns of le fort fracture lines using computed tomography scan: An observational study. *Acta Odontol Scand*. 2014;**72**(8):984-8.
10. Chen WJ, Yang YJ, Fang YM, Xu FH, Zhang L, Cao GQ. Identification and classification in le fort type fractures by using 2D and 3D computed tomography. *Chin J Traumatol*. 2006;**9**(1):59-64.
11. Beogo R, Bouletreau P, Konsem T, Traore I, Coulibaly AT, Ouedraogo D. Wire internal fixation: An obsolete, yet valuable method for surgical management of facial fractures. *Pan Afr Med J*. 2014;**17**:219.
12. Steidler NE, Cook RM, Reade PC. Incidence and management of major middle third facial fractures at the royal Melbourne hospital. A retrospective study. *Int J Oral Surg*. 1980;**9**(2):92-8.
13. Girotto JA, MacKenzie E, Fowler C, Redett R, Robertson B, Manson PN. Long-term physical impairment and functional outcomes after complex facial fractures. *Plast Reconstr Surg*. 2001;**108**(2):312-27.
14. Jarupoonphol V. Surgical treatment of le fort fractures in ban pong hospital: Two decades of experience. *J Med Assoc Thai*. 2001;**84**(11):1541-49.
15. Adebayo ET, Ajike OS, Adekeye EO. Analysis of the pattern of maxillofacial fractures in kaduna, nigeria. *Br J Oral Maxillofac Surg*. 2003;**41**(6):396-400.
16. Al Ahmed HE, Jaber MA, Abu Fanas SH, Karas M. The pattern of maxillofacial fractures in sharjah, united arab emirates: A review of 230 cases. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2004;**98**(2):166-70.
17. Deogratius BK, Isaac MM, Farrid S. Epidemiology and management of maxillofacial fractures treated at muhimbili national hospital in Dar es Salaam, Tanzania, 1998-2003. *Int Dent J*. 2006;**56**(3):131-4.
18. Mohajerani SH, Asghari S. Pattern of mid-facial fractures in Tehran, Iran. *Dent Traumatol*. 2011;**27**(2):131-4.
19. Adeyemo WL, Taiwo OA, Ladeinde AL, Ogunlewe MO, Adeyemi MO, Adepoju AA. Mid-facial fractures: A 5-year retrospective review in a Nigerian teaching hospital. *Niger J Med*. 2012;**21**(1):31-5.
20. Ykeda RB, Ballin CR, Moraes RS, Ykeda RB, Miksza AF. Epidemiological profile of 277 patients with facial fractures treated at the emergency room at the ENT department of hospital do trabalhador in curitiba/PR, in 2010. *Int Arch Otorhinolaryngol*. 2012;**16**(4):437-44.
21. Bellamy JL, Mundinger GS, Reddy SK, Flores JM, Rodriguez ED, Dorafshar AH. Le fort II fractures are associated with death: A comparison of simple and complex midface fractures. *J Oral Maxillofac Surg*. 2013;**71**(9):1556-62.
22. Oliveira-Campos GH, Lauriti L, Yamamoto MK, Junior RC, Luz JG. Trends in le fort fractures at a South American trauma care center: Characteristics and management. *J Maxillofac Oral Surg*. 2016;**15**(1):32-7.
23. Salonen EM, Koivikko MP, Koskinen SK. Violence-related facial trauma: Analysis of multidetector computed tomography findings of 727 patients. *Dentomaxillofac Radiol*. 2010;**39**(2):107-12.
24. Lee KH. Interpersonal violence and facial fractures. *J Oral Maxillofac Surg*. 2009;**67**(9):1878-83.
25. Salonen EM, Koivikko MP, Koskinen SK. Multidetector computed tomography imaging of facial trauma in accidental falls from heights. *Acta Radiol*. 2007;**48**(4):449-55.
26. Lee SS, Huang SH, Wu SH, Sun IF, Chu KS, Lai CS, et al. A review of intraoperative airway management for midface facial bone fracture patients. *Ann Plast Surg*. 2009;**63**(2):162-6.
27. Zandi M, Saleh M, Seyed Hoseini

SR. Are facial injuries caused by stumbling different from other kinds of fall accidents? *J Craniofac Surg*. 2011;**22**(6):2388-92.

28. Maladiere E, Bado F, Meningaud JP, Guilbert F, Bertrand JC. Aetiology and incidence of facial fractures sustained during sports: A prospective study of 140 patients. *Int J Oral Maxillofac Surg*. 2001;**30**(4):291-5.

29. Rhea JT, Novelline RA. How to simplify the CT diagnosis of le fort fractures. *AJR Am J Roentgenol*. 2005;**184**(5):1700-5.

30. Holmgren EP, Bagheri S, Bell RB, Bobek S, Dierks EJ. Utilization of tracheostomy in craniomaxillofacial trauma at a level-1 trauma center. *J Oral Maxillofac Surg*. 2007;**65**(10):2005-2010.

31. McRae M, Frodel J. Midface fractures. *Facial Plast Surg*. 2000;**16**(2):107-13.

32. Amin M, Dill-Russell P, Manisali M, Lee R, Sinton I. Facial fractures and submental tracheal intubation. *Anaesthesia*. 2002;**57**(12):1195-99.

33. Guven E, Ugurlu AM, Kuvat SV, Kanliada D, Emekli U. Minimally invasive approaches in severe panfacial fractures. *Ulus Travma Acil Cerrahi Derg*. 2010;**16**(6):541-5.

34. Lee C, Czerwinski M. Applications of the endoscope in facial fracture management. *Semin Plast Surg*. 2008;**22**(1):29-36.

35. Hendrickson M, Clark N, Manson PN, Yaremchuk M, Robertson B, Slezak S, et al. Palatal fractures: Classification, patterns, and treatment with rigid internal fixation. *Plast Reconstr Surg*. 1998;**101**(2):319-32.

36. Bell RB, Kindsfater CS. The use of biodegradable plates and screws to stabilize facial fractures. *J Oral Maxillofac Surg*. 2006;**64**(1):31-9.

37. Devine M, O'Regan B. Screw-wire osteo-traction (SWOT) in the reduction and fixation of frontonasal dysjunction in le fort II/III upper mid-facial fractures. *Br J Oral Maxillofac Surg*. 2013;**51**(8):985-7.

38. Kummoona R. Management of maxillofacial injuries in Iraq. *J Craniofac Surg*. 2011;**22**(5):1561-6.

39. Soong PL, Schaller B, Zix J, Iizuka T, Mottini M, Lieger O. The role of postoperative prophylactic antibiotics in the treatment of facial fractures: A randomised, double-blind, placebo-controlled pilot clinical study. Part 3: Le fort and zygomatic fractures in 94 patients. *Br J Oral Maxillofac Surg*. 2014;**52**(4):329-33.

40. Hasler RM, Exadaktylos AK, Bouamra O, Benneker LM, Clancy M, Sieber R, et al. Epidemiology and predictors of cervical spine injury in adult major trauma patients: A multicenter cohort study. *J Trauma Acute Care Surg*. 2012;**72**(4):975-81.

41. Garri JI, Perlyn CA, Johnson MJ, Mobley SR, Shatz DV, Kirton OC, et al. Patterns of maxillofacial injuries in powered watercraft collisions. *Plast Reconstr Surg*. 1999;**104**(4):922-7.

42. Rajkumar GC, Ashwin DP, Singh R, Prashanth R, Rudresh KB. Ocular injuries associated with midface fractures: A 5 year survey. *J Maxillofac Oral Surg*. 2015;**14**(4):925-9.

43. Ruslin M, Wolff J, Boffano P, Brand HS, Forouzanfar T. Dental trauma in association with maxillofacial fractures: An epidemiological study. *Dent Traumatol*. 2015;**31**(4):318-23.

44. Mundinger GS, Dorafshar AH, Gilson MM, Mithani SK, Manson PN, Rodriguez ED. Blunt-mechanism facial fracture patterns associated with internal carotid artery injuries: Recommendations for additional screening criteria based on analysis of 4,398 patients. *J Oral Maxillofac Surg*. 2013;**71**(12):2092-2100.