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Review Article

Changes in maxillary perfusion following Le Fort I osteotomy in orthognathic surgery

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Abstract

Le Fort I osteotomy is a surgical procedure that can be used in adaptation of abnormally positioned jaws, skeletal malocclusions, aesthetic operations, treatment of obstructive sleep apnea, access to tumors with intracranial extensions and in other types of skull base surgery. The main problems in Le Fort I osteotomy which is performed using various techniques directed to the maxilla are intraoperative bleeding and impaired blood supply of the osteotomized segment. Results of studies evaluating the perfusion of the maxilla during and after Le Fort I osteotomy were reviewed in the present study.

Vascular events occurring during surgery should be better acknowledged in order to prevent complications such as intraoperative insufficient maxillary perfusion or postoperative bleeding. Maxillary perfusion after maxillary downfracture depends on palatal and posterior buccal soft tissue pedicles. The conclusions from previous extensive studies on maxillary blood supply after downfracture have shown that a properly performed single-segment Le Fort I osteotomy is predictable and safe. However, factors such as multisegmentalization of the maxilla, traction of the pedicle as a result of significant dentoosseous reposition, routine ligation or traction of descending palatine artery, hypotensive anesthesia, transverse laceration in the palatal soft tissues, compression, and pre-existing scar tissue adversely affect the blood flow from these pedicles to the maxillary hard and soft tissues.

As a result, it can be suggested that complications related to intraoperative and postoperative perfusion of maxilla in Le Fort I osteotomy are rare and this surgery is safe.

Keywords: Le Fort I osteotomy; maxilla; perfusion

INTRODUCTION

Maxillary osteotomy surgery is a frequently applied surgical procedure in the adaptation of abnormally positioned jaws and skeletal malocclusions or for aesthetic reasons. It is also a method used in the treatment of obstructive sleep apnea, in approaching tumors with intracranial extensions and in other skull base surgeries (1). Le Fort I surgery was first performed in Germany by Von Langenbeck in a nasopharyngeal polyp surgery in 1859 (2). It was performed for the first time in America by Cheever in a nasopharyngeal tumor resection operation in 1864 (3). Le Fort I osteotomy originally described by the French surgeon Rene Le Fort in 1901 defines a mid-facial fracture pattern starting from the nasal septum and extending to the pterygomaxillary junction via to the dental roots (1,3). Wassmund is the first surgeon to perform osteotomy at Le Fort I level to correct mid-face deformities (2). Preserving intraoperative and postoperative blood supply of the maxilla is very important for the success of this surgical procedure which has been commonly performed in maxilla from the past to the present.

The aim of this study is to review the studies evaluating intraoperative and postoperative blood supply of maxilla in Le Fort I osteotomy and to provide a general information on this subject.

Le Fort I Osteotomy Technique

Le Fort I osteotomy technique has variable modifications according to the surgeon performing the procedure. Following, the generally applied technique is presented.

The soft tissue incision from the maxillary first molar to the first molar is made 5-10 milimeters above the mucogingival border including mucosa, muscle and periosteum with scalpel and electrocautery adjusted to the low levels (2). Dissection is ended at the level of infraorbital neurovascular bundle superiorly and at around zygomaticomaxillary buttress laterally (3). Anterior nasal spina and pyriform rim are also dissected with the periosteum elevator. Dissection is continues in the nasal mucosa, pyriform rim and maxillary crest starting from the superolateral and to the inferior and medial sites with a freer or cottle elevator. The nasal mucosa is carefully separated from the caudal septum. Subsequently, the

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elevator is directed to the posterior and the nasal mucosal dissection is completed by dissection of the inferior turbines towards the superolateral site (2). Reference markings for bone incisions are made with a surgical bur or a sterile pen after the maxilla is exposed (3,4). The first osteotomy line is applied bilaterally 4-5 milimeters above the canine and molar teeth that have the longest roots (2,4). This distance is important for the vitality of the teeth. The osteotomy line is parallel to the occlusal plane; however it can be angled according to the planned movement of the maxilla (2). Osteotomy is performed bilaterally from the lateral maxillary buttress to the pyriform rim by a surgical saw or piezoelectric saw. Before starting the osteotomy of the lateral wall of the nose, a periosteum elevator is placed subperiostally under the inferior turbine and its forwarded approximately for 2 centimeters. In this way, the nasal mucosa is preserved during osteotomy (2), (3). A long curved osteotome is then placed towards the pterygomaxillary junction, inferior to the horizontal osteotomy line. The osteotome is placed at the junction by directing it to the anterior, medial and inferior sites. One finger is placed intraorally on the hamulus before the osteotome is hammered. In this way, separation of the pterygomaxillary junction can be managed (2). It is important to prevent a possible maxillary artery injury during the osteotomy of the pterygomaxillary junction. To accomplish this, a retractor should be placed under the periosteum before starting the osteotomy in this area. A similar osteotomy is performed on the other side.

A thin osteotome is then used to complete the osteotomy posterior to the lateral and medial maxillary buttresses. The nasal septum is separated from the maxilla with a U-shaped osteotome. When osteotomies are completed, downfracture should be easily achieved by using finger pressure and no excessive force should be applied. Osteotomies should be revised if finger pressure is not enough. Excessive force applied at this stage can lead to unfavourable fractures and complications (3). Since the maxilla is free after downfracture, the soft tissue should be stretched to provide more mobility with mobilization forceps or finger pressure. Blood flow to the Le Fort I segment is provided by the ascending palatine artery which is a branch of the facial artery, and the anterior branch of the ascending pharyngeal artery. Once downfracture and mobilization is completed, aesthetic needs and preoperative planning will determine the new position of the maxilla. The maxilla should be fixed with titanium miniplates and screws in its new position. The incision is sutured with horizontal matress suturing technique with 3.0 or 4.0 Vicryl without leaving any dead spaces (2-4).

Effect of Soft Tissue Incision Techniques on Perfusio

Soft tissue incision is performed using a scalpel or electrocautery in Le Fort I osteotomy during orthognathic surgery. Scalpels have been used for many years because of their easy use, their precision and minimal damage to the surrounding tissues. The use of electrocautery in the incision provides improved hemostasis by sealing the blood vessels. However, incisions made using electrocautery can damage muscle fasciculation and cause delayed wound healing due to extensive thermal damage compared to the scalpel-guided surgical approach (5). The use of high-power lasers, which is another incision method, in dentistry and medicine is gradually increasing and has become the gold standard in many oral and maxillofacial procedures (6). In a study involving Le Fort I patients, high-power laser incision was evaluated, and as a result, circumvestibular incision made with high-power lasers was found safe and effective. It was also evaluated that postoperative pain, edema, bleeding and operation time were less (7).

Maxillary blood supply

The blood supply of the oral cavity and hard palate is provided by the maxillary, facial and ascending pharyngeal arteries which are the branches of the external carotid artery. The hard palate mucosal blood flow is provided by the major palatine artery which is a branch of the descending palatine artery that originates from the maxillary artery (8). The major palatine artery proceeds to the anterior maxilla, making an anostomosis with the nasopalatine artery without entering the incisive foramen. The nasopalatine artery enters the incisive canal to provide the blood flow of the anterior region of the hard palate (9). The major palatine artery also joins the Kiesselbach's plexus that plays a role in nasal septum perfusion. The anterior ethmoidal artery which is a branch of the ophthalmic artery, the sphenopalatine artery that is the terminal branch of the maxillary artery, and the superior labial artery which is a branch of the facial artery are other arteries that form this plexus (10).

Perfusion of the soft palate is provided by the ascending palatine artery which is a branch of the facial artery, the ascending pharyngeal artery and minor palatine arteries that are the branches of the descending palatine artery (8).

Association of Le Fort I osteotomy and maxillary blood flow

As with all surgical procedures, Le Fort I osteotomy has general and specific complications and is accepted as a safe surgical procedure with a complication rate of 6.4% (11). The main problems in Le Fort I osteotomy which is performed using various techniques are intraoperative bleeding and impaired blood supply of the osteotomized segment (1). Descending palatine arteries might be injured during Le Fort I osteotomy (8). Inadequate perfusion and eventually ischemia is a serious complication that can lead to loss of hard and soft tissue (1). Complications that might be seen after Le Fort I osteotomy are infection, periodontal defects, pulpal changes, poor union or nonunion, partial or total maxilla necrosis and rarely postoperative bleeding (12,13). Vascular events during surgery should be better acknowledged in order to prevent complications such as intraoperative insufficient maxillary perfusion or postoperative bleeding (12).

Perfusion of the maxilla after maxillary downfracture dep ends on palatal and posterior buccal soft tissue pedicles (14). Previously published extensive studies on maxillary blood supply after downfracture have shown that a properly performed monosegment Le Fort I osteotomy is predictable and safe (15). However factors such as multisegmentalization of the maxilla, traction of the pedicle as a result of significant dentoosseus reposition, routine ligation or traction of descending palatine artery, hypotensive anesthesia, transverse laceration in the palatal soft tissues, compression, and pre-existing scar tissue adversely affect the blood flow from these pedicles to the maxillary hard and soft tissues (14,16). Ligation of these arteries is not recommended unless the descending palatine artery is damaged or is bleeding or a posterior maxillary impaction planned. Nevertheless, unilateral or bilateral ligation of the artery does not increase the risk of avascular necrosis (12,17). Some surgeons prefer routine ligation of the artery due to the risk of late postoperative nasal bleeding when it is not ligated, although rare (2). If intraoperative venous or unidentified bleeding develops, bleeding can be controlled with electrocautery, vasoconstrictor-moistened sponge, microfibrillar collagen and reverse-Trendelenburg position.Uncontrolled bleeding can usually be treated with angiographic embolization in interventional radiology suite (18,19). In such cases, external carotid artery ligation has been reported to be minimally effective (19).

Aseptic necrosis in the maxillary dental pulp, periodontal tissue and / or dentoalveolar segment was reported in 36 cases in a study on maxillary osteotomy. In that study, cases of aseptic necrosis were described as a case series and multisegmentalization of the maxilla was emphasized to increase the risk (20). Aseptic necrosis can be seen in a wide range of tooth vitality losses, periodontal defects, alveolar bone losses, tooth losses, partial maxilla necrosis and total maxilla necrosis. Smoking and iatrogenic factors, excessive bleeding, extensive hypotension, ligation of the external carotid artery, or embolization are among the factors (20). The incidence of aseptic necrosis is higher in multisegmental osteotomies compared to monosegment osteotomies and the risk increases as the number of segments increases. However, this risk has been shown to be 1% in multisegmental osteotomies. Smoking and iatrogenic factors are among the causes of aseptic necrosis (2). Pulpal tissues tend to tolerate decreased vascularity quite well after Le Fort I osteotomy. Dental vitality test is not reliable in the immediate postoperative period, as 6% to 29% of the teeth can give a devital result up to 54 months postoperatively (21). Pulpal necrosis develops very rarely. Since spontaneous revascularization may develop, endodontic treatment should be delayed until at least 8 weeks postoperatively (22).

Evaluation of Blood Flow

Some devices and systems have been used to evaluate the maxillary blood supply after Le fort I osteotomy. In previous studies, perfusion of maxilla was evaluated with subjective data such as mucosal and gingival discoloration. More objective techniques such as thermography and angiography have also been used; however, these techniques are invasive and time consuming with no option of continuous or intraoperative measurement (23).

Laser-Doppler flowmetry (LDF) has been used to measure blood flow, especially in soft tissues, since 1964, when it was discovered by Yeh and Cummins (24). After its use in that study to measure blood flow in hard tissue, Ramsay et al. used the device to measure pulpal blood flow (25). It is noninvasive, ergonomic, harmless and requires no visual assessment and the blood flow can be continuously measured and thus, it has become a preferred technique in many animal and human studies. Intraoperative blood flow measurement can also be made with LDF (23,26,27). However, a precise blood flow measurement can not be made and relative measurements can be performed. Blood flow of the tongue, buccal mucosa, periodontal tissue, masseter muscle, pulp and luxated teeth, as well as of the skin, retina, intestine, kidney and bone could be evaluated with LDF (27).

Another technique of blood flow measurement is using Xenon 133 radioisotope, a radioactive indicator. It was used to measure blood flow for the first time by Lassen et al. Its limited use in humans and requirement of special license are disadvantages of the technique, and also it is expensive (28).

Devices that can measure dynamic perfusion using indocyanine green dye have also been developed. Although they have advantages such as providing dynamic images during surgery and require no interpretation, they are expensive systems (15).

Studies Evaluating the Effects of Le Fort I Osteotomy on the Intraoperative and Postoperative Perfusion of the Maxilla

In studies comparing osteotomy techniques, the blood supply of the maxilla or the maxillary segments formed as a result of different techniques such as monosegmental, multisegmental, horseshoe, gingival blood flow (GBF) and pulpal blood flow (PBF) were evaluated.

No significant difference was found between the segments (right and left lateral segments and premaxilla) in a study evaluating the blood flow before (T1) and after (T2) Le Fort I and after maxillary segmentalization and fixation (T3) by LDF in 12 patients who had underwent multisegmental Le Fort I osteotomy and sagittal split ramus osteotomy. However, the decrease in the blood flow of the segments was found significant in the T1-T2 and T2-T3 time intervals (29).

In another study evaluating different Le Fort I osteotomy techniques, patients were divided into two groups.

Posterior maxillary osteotomy was made at the pterygomaxillary junction in group 1 (n = 19) and at the 3rd molar tooth socket in group 2 (n = 19). Multisegmental maxillary osteotomy was performed in 8 patients in group 1 and 5 patients in group 2. Measurements were made on the anterior maxillary gingiva by LDF preoperatively (T0), after intubation (T1), after downfracture (T2), after fixation of the maxilla (T3) and after extubation (T4) . In both groups, the decrease in blood flow was found to be significant through the measurements from T0 to T4 (P <0.001). Maxillary movements and different osteotomies applied in posterior maxilla resulted in no significant differences between the two groups (1).

In another study comparing different Le fort I osteotomy techniques, patients were divided into two groups as with horseshoe osteotomy (n = 9) and monosegment osteotomy (n = 14). In the horseshoe technique, after the downfracture, first a transverse palatal osteotomy from the anterior nasal base to the oral cavity is completed and subsequently bilateral sagittal osteotomies from the tubercular maxilla to the transverse palatal osteotomy are performed. Thus, the maxilla is divided into two parts as palatal and dentoalveolar segments. No incision is made to the palatinal mucoperiosteum. It is aimed to keep the descending palatal artery in its original position in the palatal segment in this technique. In the horseshoe osteotomy group, the dentoalveolar segment of the maxilla was embedded in average 5 milimeters, and in the monosegment osteotomy group, the maxilla was positioned anteriorly in average 5 milimeters. Pulpal blood flow (PBF) was measured in 32 and 54 intact anterior incisors in the horseshoe and monosegmental osteotomy groups, respectively. Evaluations using LDF were performed preoperatively and at 1-7 days, 14 days, and 3, 6 and 12 months postoperatively. The measurement made on the first postoperative day resulted in the lowest value in both groups. This value was significantly higher in the horseshoe osteotomy group (P <0.01). The mean value on day 4 was significantly higher in the horseshoe osteotomy group (P <0.01). Higher PBF values were observed in the monosegmental osteotomy group on the 7th and 14th days (P <0.05 and P <0.01, respectively) (24).

In another study comparing multisegmental and monosegment Le Fort I osteotomy techniques, patients were divided as a study group that had multisegmental (n = 14) or monosegment (n = 12) Le Fort I osteotomies and a control group that had no surgical or orthodontic treatment (n = 12) . PBF of the maxillary incisors, canines and premolar teeth of the patients were evaluated using LDF preoperatively (session I), on postoperative days 3-5 (session II), and on day 55 and 59. More than 40% drop in PBF was considered as a negative result. PBF was significantly lower in the Le Fort I osteotomy group (P =.000). Patients who had multisegmental Le Fort I osteotomy had a significantly lower PBF in canine tooth in session II compared to session I (P =.004) (26).

Considering these studies, it can be said that perfusion is decreased in the postoperative early measurements, regardless of the technique, but is normalized in the following days.

Thanks to the micromovements provided by the ultrasonic devices developed based on the great demand for minimally invasive osteotomy, the damage that may occur in the soft tissues adjacent to the osteotomy was reduced (30). Vercelotti introduced the piezosurgery (piezoosteotomy) device that caused less bleeding in 2001 (31,32). Mineralized tissue osteotomy is possible in piezosurgery with 24 to 29 kHz 60 to 200 μm / s microvibrations without causing soft tissue damage. However, with frequencies above 50 kHz, soft tissue is compromised (33,34). In histological and histomorphometric studies in experimental animals, piezosurgery has been found to be better in wound healing and bone formation than traditional osteotomy techniques with diamond or carbide burs (35). It has advantages such as greater increase in bone morphogenetic proteins after osteotomy, better preservation of neurovascular structures, and better surgical vision than traditional methods (36).

Patients were followed-up for long and short-terms in various studies evaluating patients with maxillary surgery, no surgery and mandibular surgery. In some of the following studies, the effect of Le Fort I osteotomy on blood supply was evaluated with comparisons to surgical control groups.

In a randomized clinical study evaluating the maxillary gingival blood flow (GBF) of patients undergoing Le fort I osteotomy, patients were compared by dividing into two groups where the descending palatine artery was ligated (group 1, n =16) or protected (group 2, n =18). Measurements were performed by LDF at four different time points as before general anesthesia (T0), immediately after endotracheal intubation (T1), post-downfracture (T2), and after descending palatine artery ligation in group 1, 3 minutes after T2 in group 2 (T3), and immediately after extubation (T4). No significant difference was found between the two groups at the time points during the measurements (12).

The blood flow of maxillary teeth was evaluated in a study involving 14 patients (study group) who underwent Le Fort I osteotomy, 7 patients (surgical control group) who underwent bilateral sagittal split ramus osteotomy (BSSRO) and 7 patients (control group) without surgery. Measurements were made in the first week, and in months 1, 3, 6, 9 and 12 with LDF in maxillary incisors, canines and first premolar teeth. As a result, there was no significant difference between the groups (37).

In another prospective cohort study evaluating perfusion of maxilla during Le Fort 1 osteotomy, the study group (n =14) was composed of patients who had Le Fort I osteotomy (with or without mandibular osteotomy), and the control group (n =8) composed of patients who had isolated mandibular osteotomy. Blood loss during surgery was significantly higher in the study group as expected. The average number of segments of the maxilla in the study group was 1.9 ± 0.8. Measurements were performed using LDF before general anesthesia (T0); post-intubation (T1); 5 minutes after local anesthesia injection with vasoconstrictor content (T2); after soft tissue dissection (T3); after downfracture and mobilization of maxilla (T4); after fixation of maxilla (T5); and finally, before the surgical drapes were removed at the end of the case (T6). In this study in which anterior maxillary GBF was evaluated and the groups were compared, the mean GBF did not differ significantly in the control group, but decreased significantly in the study group. GBF was found to be significantly lower in the study group (P = 0.0001) (23).

In another study evaluating the pulpal blood flow in 54 incisors of 14 patients who underwent Le Fort I osteotomy preoperatively, on postoperative day 1-7, day 14 and months 1, 3, 6 and 12, no significant decrease was found in the blood flow compared to the preoperative measurements except in day 1 (p <0.05), day 7 (p <0.05) and day 14 (p <0.01) (38).

In another study evaluating the effect of Le fort I osteotomy on the maxillary pulpal and gingival blood flow, patients were divided into three groups. The study group consisted of 12 patients who had Le Fort I osteotomy (8 patients had monosegment osteotomy, 4 patients had multisegmental osteotomy), the surgical control group consisted of 9 patients who had mandibular osteotomy, and the control group consisted of 10 patients with no surgery. PBF values were obtained from maxillary central teeth and measurements were made preoperatively and postoperatively at 0-8 hours, 8-16 hours and 16-24 hours with LDF. In each session, appropriate splints were used for patients to fit the probe to the tooth and gum as specified. As a result, GBF decreased significantly in the study group and surgical control group (P <0.001, P <0.05, respectively). In the postoperative measurements, it was observed that GBF decreased significantly in the study group compared to the surgical control group, except for the measurements in the 0-8 hours interval. PBF was found to be significantly low in the study group, while there was no significant decrease in the surgical control group. There was no significant difference between the two surgical groups (39).

Considering intraoperative measurements, it can be said that surgical procedures cause a significant decrease in both gingival and pulpal blood flow. Studies with a postoperative 1-year follow-up showed that this decrease in perfusion was temporary.

Apart from these studies, cases of aseptic necrosis in the maxilla after Le Fort I osteotomy have also been reported (20). There is no consensus in the treatment protocol for aseptic necrosis (2). However, when such a rare condition is encountered, recommended measureas are providing a good oral hygiene, saline irrigation of the necrotic area, hyperbaric oxygen therapy to limit necrosis and antibiotherapy to prevent secondary infection. Surgical debridement also allows the necrotic tissue to dissolve faster. Reconstruction of the defect after debridement can be achieved with soft tissue flaps, autogenous bone grafts and alloplastic graft materials (14,20).

CONCLUSIONS

Le Fort I osteotomy is frequently used to correct midfacial deformities.

In Le Fort I osteotomy, conditions such as damage to the descending palatine artery or routine ligation of it were considered to have a negative effect on the perfusion of the maxilla; however it was found not to increase the risk of aseptic necrosis. Performing of the operation under hypotensive anesthesia adversely affects the intraoperative blood supply of the maxilla or osteotomized segments. In addition, hypotensive anesthesia prevents the obscured vision due to bleeding and almost eliminates the need for postoperative blood transfusion. The negative effects of hypotensive anesthesia on perfusion of maxillary can be seen but these effects reversible and for short-term besides can be ignored due to its advantages. Also, it is concluded that performing a posterior maxilla osteotomy from the 3rd molar tooth socket or pterygomaxillary junction in Le Fort I osteotomy has no significant effect on the blood supply of the maxilla. Another result is that monosegment Le Fort I osteotomies have a better effect on maxillary blood supply compared to multisegmental osteotomies.

Based on these studies, it can be concluded that complications related to intraoperative and postoperative perfusion of maxilla are rare in Le Fort I osteotomy and this surgery is safe.

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