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VASCULAR CONSIDERATIONS IN THE LE FORT I OSTEOTOMY: results of analysis of 16 cases

Considerações vasculares na osteotomia Le Fort I: resultados da análise de 16 casos

Ophir Ribeiro Júnior[a], Alexandre Meireles Borba[a], Celso Luiz Ferraz[b], Jayro Guimarães Júnior[c]

[a] Cirurgião Buco-Maxilo-Facial, MsC, São Paulo, SP - Brasil, e-mail: ophirrj@usp.br; ophirrj@ig.com.br
[b] Cirurgião Buco-Maxilo-Facial, Serviço de CTBMF, Hospital Universitário, Universidade de São Paulo (USP), São Paulo.
[c] Professor, PhD, Estomatologia, Clínica de Estomatologia, Faculdade de Odontologia, Universidade de São Paulo (USP), São Paulo, SP - Brasil.

Abstract

OBJECTIVE: To review the vascular principles of the Le Fort I osteotomy together with a retrospective analysis of the following factors in 16 cases: ligature of the descending palatine arteries, bone segmentations and the types of surgical movements. RESULTS AND DISCUSSION: Mild complications occurred in two patients who had osteotomies in two places. Both had ligature of the palatine descending arteries and superior repositioning with impaction of the posterior maxilla greater than 4 mm. CONCLUSION: According to the literature and the obtained results, the Le Fort I osteotomy without segmentation presents as a very safe procedure for the correction of maxillary deformities. The ligature of the descending palatine artery does not seem to directly affect the occurrence of ischemic sequelae, except when associated with segmentations and major surgical movements.

Key words: Osteotomy; Le Fort; Maxilla; Blood supply.

Resumo

OBJETIVO: Revisar os princípios vasculares da osteotomia Le Fort I, juntamente com uma análise retrospectiva dos seguintes fatores, em 16 casos: ligadura da artéria palatina descendente, segmentação óssea e tipos de movimentos cirúrgicos. RESULTADOS E DISCUSSÃO: Complicações discretas ocorreram em dois pacientes submetidos a osteotomias em dois lugares. Ambos tiveram as artérias palatinas desligadas e reposição superior com impactação da maxila posterior maior do que 4 mm. CONCLUSÃO: De acordo com a literatura e os resultados obtidos, a osteotomia Le For I sem segmentação é um procedimento muito seguro para a correção das deformidades maxilares. A ligadura da artéria descendente palatina parece não afetar diretamente a ocorrência de seqüelas isquêmicas, exceto quando associada com segmentação e movimentos maxilares extensos.

Palavras chave: *Osteotomia; Le Fort. Maxila; Suprimento sanguíneo.*

INTRODUCTION

Total maxillary osteotomy, known as Le Fort I by analogy to midface fractures, is an important technique for the correction of dentofacial deformities. This versatile and safe osteotomy is a result of decades of training in orthognathic surgery. However, many professionals remain concerned about the possibility of ischemic complications, which can compromise the descending palatine arteries, in special when the procedure requires segmentations to correct the deformity. Such complications include dehiscence, periodontal defects, teeth devitalization, nonunion and partial or complete loss of the maxilla (1-6).

The present study presents a clinical analysis of 16 cases submitted to this osteotomy, evaluating bone healing in situations such as ligature of the descending palatine artery, bone segmentation and different types of surgical movement.

MATERIALS AND METHODS

Clinical cases

During the period from October 2004 through February 2006, 16 patients without previous vascular pathology underwent a Le Fort I osteotomy. The patient's age varied from 19 to 35 years old (mean = 25.5). The study included eight men and eight women (50% each gender). Malocclusion and deformity types observed in the three planes of the maxilla are listed in Table 1. Patients received preoperative planning and were submitted to orthognathic surgery according to the following protocol (7-9), which has been used by the authors for some years.

TABLE 1 - Profile of studied patients regarding age, gender, malocclusion and maxillary deformity in sagittal, frontal and transversal planes (M=male, F=female)

Patients	Age	Gender	Malocclusion	Maxillary deformity in spatial planes		
				Sagittal	Frontal	Transversal
Case 1	22a	F	Class III	Retrusion	Vertical excess/ asymmetry	Atresia
Case 2	31a	M	Class III	Retrusion	Vertical excess/ asymmetry	Normal
Case 3	24a	F	Class III	Retrusion	Normal	Atresia
Case 4	30a	M	Class III	Retrusion	Vertical insufficiency	Normal
Case 5	21a	M	Class II	Retrusion	Vertical excess	Normal
Case 6	25a	F	Class III	Retrusion	Vertical insufficiency / asymmetry	Normal
Case 7	35a	F	Class III	Retrusion	Vertical insufficiency	Normal
Case 8	20a	F	Class III	Normal	Asymmetry	Normal
Case 9	19a	M	Class III	Retrusion	Asymmetry	Normal
Case 10	24a	F	Class III	Retrusion	Vertical excess	Normal
Case 11	21a	M	Class III / anterior open bite	Normal	Asymmetry	Normal
Case 12	22a	M	Class III / anterior open bite	Retrusion	Vertical insufficiency / asymmetry	Normal
Case 13	31a	F	Class II	Normal	Vertical excess	Normal
Case 14	28a	M	Class II	Retrusion	Normal	Normal
Case 15	25a	M	Class II	Protrusion	Vertical excess	Normal
Case 16	34a	F	Class III	Retrusion	I Vertical insufficiency	Normal

Planning protocol

The position of the maxilla in the frontal and sagittal planes was clinically determined by means of facial analysis according to the principles established by Arnett and Bergman [7,8], while the transversal dimensions were obtained from model analysis. Lateral cephalogram tracings were used as diagnostic auxiliary and for quantitative measurement of the maxillary movements in the sagittal plane before model surgery (Figure 1).

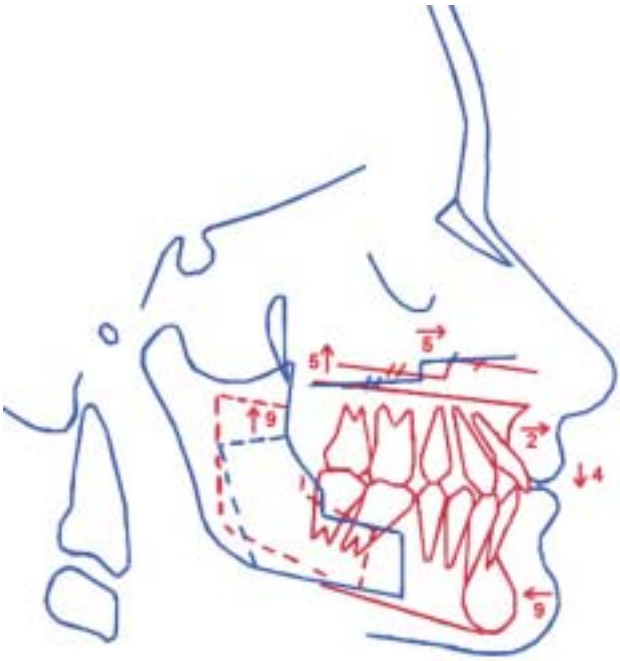

FIGURE 1 - Predictive tracing using the lateral cephalogram, highlighting planned surgical movements for the maxilla and the mandible in the sagittal plane

At the frontal plane, it was considered as asymmetry the inclination of the maxillary vertical growth "Z" axis in relation to the true horizontal line, which follows parallel to the ground. This inclination was determined by the disposition of a wooden spatula tangent to the canines' incisal edges while maintaining the patient`s head in a naturally oriented position (Figure 2). The transversal dimension was evaluated after preoperative orthodontics since some cases (15 and 16) had the discrepancy treated with surgically assisted rapid palatal expansion.

FIGURE 2 - Evaluation of the maxillary inclination on the Z axis relating to the true horizontal line (in red)

Surgical considerations

With the exception of case 3, all surgeries were performed in both the maxilla and mandible (double-jaw surgery) and started from the mandible because, in the authors' opinion, this sequence reproduces more truly the planned movements, including the maxillary ones. All cases were operated with a sublabial approach and Le Fort I osteotomy with a vertical step at the zygomatic buttress (Figure 3). The criterion for descending palatine artery ligature was established intraoperatively in all cases.

FIGURE 3 - Surgical view of the Le Fort I osteotomy (after fixation). Observe the surgical approach and the vertical step on the zygomatic buttress

In cases submitted to anterior segmentation (cases 1, 11 and 12), the orthodontic preparation included divergence between the lateral incisor and the canine roots. In all of these cases, the gingival mucosa was detached in order to perform the osteotomy with an oscillatory saw and chisel before downfracture of the maxilla. After the conclusion of the Le Fort I osteotomy and downfracture, the segment osteotomy was completed with an oscillatory saw from the nasal side, with care not to perforate the palatine mucosa (Figure 4).

FIGURE 4 - Surgical view of the segmented osteotomies between lateral incisors and canines roots (after stabilization of the interpositional bone grafts and fixation)

In the cases submitted to transverse expansion during the orthognathic procedure (cases 1 and 3), sagittal palatine incisions were performed laterally to the greater palatine artery, as described by Wolford et al. (10). The mucosa was undermined up to the midline at a level superficial to the greater palatine artery, and then incision and detachment of the periosteum were performed, thus allowing for elasticity of the expansion (Figure 5). After the release of the mucosa, sagittal osteotomies were performed tangentially to the intermaxillary suture.

FIGURE 5 - Surgical view of the lateral sagittal palatine incision, displaying periosteum detachment medial to the great palatine artery

Statistical analysis

To evaluate differences between descending palatine arteries, bone segmentation and surgical movements in the occurrence of complications, the chi-square test (c^2) modified by Yates was employed, with a significance level of 5% ($p < 0.05$).

RESULTS

The results obtained are listed in Tables 2 and 3.

TABLE 2 - Complications from Le Fort I osteotomy in relation to the ligature of descending palatine arteries, segmentations and type of surgical movement (ND = not documented; * movements unfavorable to the palatine pedicle such as advancement > 7 mm in the vertical step of the osteotomy, superior repositioning > 4 mm in the second molar region, expansion > 5 mm in the first molar region and Z-axis correction of major asymmetries). OBS= Quantification of superior movement was estimated in the preoperative period using the two dimensions of the predictive tracing, not applicable to asymmetric impactions

Patients	Descending palatine artery	Segmentation	Types of surgical movements in the maxilla	Complications
Case 1	Preserved	Yes (3 segments)	Advancement* / superior repositioning* / expansion* / Z axis correction*	None
Case 2	ND	No	Advancement* / superior repositioning / Z axis correction	None
Case 3	Preserved	Yes (2 segments)	Advancement* / expansion*	None
Case 4	ND	No	Advancement / inferior repositioning	None
Case 5	Preserved	No	Setback / superior repositioning	None
Case 6	ND	No	Advancement* / inferior repositioning / Z axis correction	None
Case 7	Ligated	No	Advancement / inferior repositioning of the anterior part / superior repositioning of the posterior part*	None
Case 8	Preserved	No	Advancement / Z axis correction*	None
Case 9	Preserved	No	Advancement / Z axis correction	None
Case 10	Preserved	No	Advancement / superior repositioning*	None
Case 11	Ligated	Yes (2 segments)	Setback and superior repositioning of the posterior part	Nonunion of the anterior segment
Case 12	Ligated	Yes (2 segments)	Advancement* / inferior repositioning of the anterior part / superior repositioning of the posterior part* / Z axis correction	Bilateral dehiscence and periodontal recession unilaterally, in the area of segmentation
Case 13	Ligated	No	Setback / superior repositioning	None
Case 14	Preserved	No	Advancement	None
Case 15	Preserved	No	Setback / superior repositioning	None
Case 16	Preserved	No	Advancement / inferior repositioning	None

TABLE 3 - Overall percentage analysis of the occurrence of complications

Cases	Total
With complications	n = 2 (12.5%)
Without complications	n = 14 (87.5%)
Total	n = 16 (100%)

Overall, complications were mild and occurred in only two patients (12.5%), including dehiscence and periodontal bone loss in the interdental area of segmentation (case 12; Figure 6) and nonunion (case 11). Such cases received treatment directed to each complication, and presented no issues that compromised the final result.

FIGURE 6 - Clinical view of the dehiscence in the region of the segmented osteotomy between teeth

The abovementioned complication affected half of the cases submitted to segmented surgery. In the two affected patients, both descending palatine arteries were ligated and superior repositioning with posterior region impaction was more than four millimeters. The percentage correlation among the occurrence of complications and the evaluated factors are detailed in Tables 4, 5 and 6. The influences of each of these factors are presented in Table 7.

TABLE 4 - Percentage analysis of the relationship among ligature of palatine descending arteries and the occurrence of complications (considering n=13 and excluding cases 2, 4 and 6, which lacked documentation about preservation of the descending palatine arteries)

Cases	Ligature of the descending palatine arteries		Total
	Yes	No	
With complications	n = 2 (15.4%)	n = 0 (0%)	n = 2 (15.4%)
Without complications	n = 2 (15.4%)	n = 9 (69.2%)	n = 11 (84.6%)
Total	n = 4 (30.8%)	n = 9 (69.2%)	n = 13 (100%)

TABLE 5 - Percentage analysis of the relationship among segmentation and occurrence of complications

Cases	Segmentation		Total
	Yes	No	
With complications	n = 2 (12.5%)	n = 0 (0%)	n = 2 (12.5%)
Without complications	n = 2 (12.5%)	n = 12 (75%)	n = 14 (87.5%)
Total	n = 4 (25%)	n = 12 (75%)	n = 16 (100%)

TABLE 6 - Percentage analysis of the relationship among movements unfavorable to the palatine pedicle and the occurrence of complications

Cases	Movements unfavorable to the palatine pedicle		Total
	Yes	No	
With complications	n = 2 (12.5%)	n = 0 (0%)	n = 2 (12.5%)
Without complications	n = 7 (43.75%)	n = 7 (43.75%)	n = 14 (87.5%)
Total	n = 9 (56.25%)	n = 7 (43.75%)	n = 16 (100%)

TABLE 7 - Resumed statistical analysis and level of significance of the criteria studied for the occurrence of complications

Complication factors	*p*-value – chi-square test (χ^2)
Descending palatine arteries ligature	$p > 0.05$
Segmentation	$p < 0.05$
Movements unfavorable to the palatine pedicle	$p > 0.05$

DISCUSSION

The principles for the Le Fort I osteotomy are based on anatomic and surgical techniques that aim to maintain the soft tissue pedicle and thereby the blood supply of bone tissue (1-4, 11, 12). The surgical approach includes limiting the incision up to the first molars bilaterally and not detaching the gingival mucosa (3, 13). By cutting the posterior superior alveolar and the nasopalatine arteries through the osteotomies of the lateral part of the maxilla and the nasal septum, the blood supply to the bone then comes from the descending palatine artery and from the microvasculature of the palate and the gingiva (14,m 15).

Experimental studies suggest the occurrence of a transient ischemic period at the maxilla after Le Fort I osteotomy (13,14,16). Although this period is responsible for most of the ischemic sequelae, Bell et al. (13) refer that such ischemia is compensated for by a vascular proliferation that allows tissue healing. Sharing this opinion, others state that this period only compromises maxillary healing in the presence of other complication factors such as the magnitude and direction of the surgical movement, multiple segmentations and the presence of underlying vascular compromise (3,15).

There are controversies related to the value of maintaining the descending palatine arteries. Aside from mobilization of the maxilla for the advancement of movement, preserving the descending palatine arteries increases postoperative bleeding risks due to possible laceration of their walls (12,16). On the other hand, their preservation optimizes healing and diminishes the risk of tissue necrosis (2,4). Ischemic sequelae seem not to be directly related to lesion or ligature of artery walls in isolation (1,15), as suggested in the present study.

Drastic reduction of the total maxillary blood flow was observed when the descending palatine arteries were ligated (16). In spite of the real vascular compromise, it has been demonstrated that the palatine pedicle is enough for the blood supply of the maxilla (17). In the absence of descending palatine arteries, the collateral microvasculature from other arteries maintains viability of this pedicle up to revascularization of the severed bone areas (17, 18)[8]. Among the arteries responsible for this vascular compensation are the ascending pharyngeal and the facial (15,18,19).

Lanigan et al (1) in a review of 36 cases of ischemic necrosis, demonstrated that these complications can occur, albeit rarely. Their data show strong relationships among bone segmentation and some surgical movements for the occurrence of such complications. Although only 13 cases had reports of ligature or lesion of the descending palatine artery, these authors recommend its preservation in order to increase the safety of the Le Fort I osteotomy, mainly in the presence of segmentation and significant movement.

Related to the segmentations, a high rate of ischemic sequelae is pointed out in the literature, affecting mainly the anterior region of the maxilla (1,15). This occurs due to lesion of bone marrow vessels, which significantly diminishes the blood supply to segments more distant to the pedicle (20). Other factors that contribute to this are: type of incision, number of bone segments, ligature of the descending palatine arteries, amount of bone-teeth repositioning, lesion of the vascular pedicle and hypotensive anesthesia (1,4,14).

Modified incisions maintaining an additional pedicle in the anterior region are proposed to minimize complications in segmented osteotomies (20). However, Bell et al .(14) demonstrated, in a histological and microangiographic study, that the vascular alterations of the segmented maxilla and the effects of the classic sublabial incision are transitory and do not impair bone healing, even when the descending palatine arteries are ligated.

Surgical movement is capable of altering the blood supply even more due to stretching, compression or laceration of the palatine pedicle (1,4,14,15,20). Movements more associated with the development of ischemic sequelae are superior repositioning, advance and expansion, in particular when the maxilla is segmented (1,10,15). In the Lanigan et al.'s study, superior repositioning was associated with complications in 19 cases, transversal expansion in 14 and advance in six, considering that in 11 cases more than one movement was performed (1).

At the superior repositioning of the maxilla, the preservation of descending palatine arteries is recommended due to the significant stretching of the palatine pedicle (1,4). In cases of transverse expansion over three millimeters at the molar region, Wolford et al. (10) emphasized the need for relieving incisions on the palate to prevent mucosal laceration. Advancement movements between seven and ten

millimeters are highly likely to stretch the palatine pedicle, thus the association of a labial pedicle might be considered when segmentation is planned in such cases (1,14,20).

The two cases that evolved complications had the descending palatine arteries ligated, in association with segmentation and unfavorable surgical movements regarding the palatine pedicle. Both cases received anterior segmentation for open-bite correction and had a superior repositioning over four millimeters at the posterior region, according to estimated values from the predictive tracing. In one of these patients (case 12), the posterior impaction was approximately 10 mm, combined with inferior repositioning of the anterior segment and a significant advancement. These observations are in contrast with case 1, where four types of significant movements were performed without the occurrence of complications. Certainly the preservation of descending palatine arteries in this case was essential for tissue healing.

Maxillary inclination in the "Z" axis is a factor that must be evaluated in segmented surgeries with great impaction on the posterior region. Once the panned movement is accomplished in two dimensions in the predictive tracing, asymmetric impactions can only be quantified by means of detailed analysis of maxillary model surgery. This preoperative evaluation is important for movement diagnosis; hence the lower side of the maxilla undergoes major impaction for superior repositioning, and then suffers more stretch in the palatine pedicle (Figure 7).

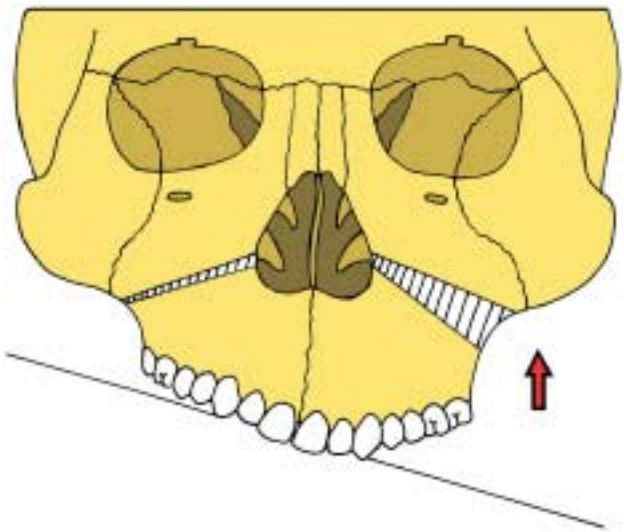

FIGURA 7 - Esquema ilustrando a impacção assimétrica da maxila, com maior amplitude de movimento no lado mais baixo

Although asymmetric superior repositioning has been evaluated in the present study, the results do not allow robust conclusions.

CONCLUSIONS

1. Conventional Le Fort I osteotomy, without segmentation, is highly safe for the correction of deformities involving the maxilla;
2. Preservation of descending palatine arteries does not seem to be determinant to vascular blood flow to the osteotomized maxilla, except in the presence of other unfavorable factors;
3. The occurrence of ischemic complications is more frequent in segmented surgery, mainly when associated with ligature of the descending palatine arteries and with movements such as superior repositioning, transverse expansion and advancement;
4. More studies are needed to evaluate vascular complications in patients with facial asymmetry.

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