



Factors Influencing Blood Loss in Orthognathic Surgery – A Retrospective Study

Habari M¹, Wåxnäs K¹, Rasmusson L^{1,2} and Walladbegi J^{1*}

¹Department of Oral and Maxillofacial Surgery, Institute of Odontology, The Sahlgrenska Academy, University of Gothenburg, Sweden

²Department of Oral and Maxillofacial Surgery, Linköping University Hospital, Sweden

Abstract

Objective: Several patients and operator related factors have been confirmed to be of importance for blood loss in orthognathic surgery, e.g., type of surgical intervention and operative time. However, the surgeon's impact has been studied only to a limited extent. Thus, the primary aim of this study was to evaluate the surgeon's impact on intraoperative blood loss.

Methods: Clinical data was gathered retrospectively for all osteotomies performed by three different experienced surgeons between January 1st, 2013 to December 31st, 2016 at a regional centre for orthognathic surgery at the Sahlgrenska University Hospital, Gothenburg, Sweden.

Results: A total of 179 patients (92 women and 87 men) who underwent Le Fort I osteotomy, Bilateral Sagittal Split osteotomy, or Bi-maxillary osteotomy were included. No statistically significant difference was seen between the three surgeons for intraoperative blood loss.

Conclusion: Intraoperative blood loss during orthognathic surgery is not operator dependent when experienced surgeons are compared.

Keywords: Bimaxillary surgery; Bilateral sagittal split osteotomy; Le Fort I

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*Correspondence:

Java Walladbegi, Department of Oral and Maxillofacial Surgery, Institute of Odontology, The Sahlgrenska Academy, University of Gothenburg, PO Box: 450 405 30, Göteborg, Sweden, Tel: + 46 (0) 735 989 754; E-mail: java.walladbegi@odontologi.gu.se

Received Date: 25 Jan 2022

Accepted Date: 07 Mar 2022

Published Date: 15 Mar 2022

Citation:

Habari M, Wåxnäs K, Rasmusson L, Walladbegi J. Factors Influencing Blood Loss in Orthognathic Surgery – A Retrospective Study. *Clin Surg.* 2022; 7: 3446.

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Introduction

Orthognathic surgical procedures are used to correct a wide range of malocclusions and maxillofacial deformities. Novel standardized planning modalities and surgical methods are generally safe and severe complications are rare but can be substantial if encountered [1]. Bleeding, intra-, and/or postoperatively is among the most recognized complication in conjunction with orthognathic surgery and is frequently documented in both operator and nursing reports [2]. During Le Fort I (LFI) osteotomy, i.e., down-fracturing and mobilizing of the maxillary segment of the viscerocranium, bleeding can occur by rupture of the maxillary artery and its collateral branches (descending palatine artery, sphenopalatine artery) or by damage to vessels in the pterygoid venous plexus [3,4]. The maxillary artery along with its terminal branches are commonly damaged in LFI osteotomy, especially during separation of the pterygomaxillary junction [5]. In contrast, hemorrhages associated with mandibular osteotomies, e.g., intra-, or extra oral vertical ramus osteotomy, or Bilateral Sagittal Split Osteotomy (BSSO), occur less frequently [3]. Nevertheless, once they ensue the hemorrhages are likely to originate from the maxillary artery or vessels in its dispersed vascular network [3]. There are several patient- and operator related factors that are of importance for blood loss. However, in previous studies a direct correlation between the complexity of the surgical interventions and intraoperative blood loss has been demonstrated. Patients who are treated with Bi-maxillary osteotomy (LFI+BSSO) have a significantly higher blood loss compared to those who receive LFI or BSSO [2,6]. Other studies have promoted that intraoperative blood loss differs with the operative time [3,7-9]. It has further been speculated, but only investigated to a lesser extent whether the surgeon has an impact on the intra operative blood loss during the aforementioned surgical procedures. Thus, the primary aim of this study was to evaluate the surgeon's impact on intraoperative blood loss. Secondary aims were to evaluate the difference in blood loss between surgical procedures, and Operative Time (OT) for each surgical procedure.

Methods

Study design

This study was a retrospective review of medical charts and databases at the Department of

Oral and Maxillofacial Surgery, a regional centre for orthognathic surgery at the Sahlgrenska University hospital, Gothenburg, Sweden. We retrospectively analyzed the patient records of all orthognathic surgery cases between January 1st, 2013 to December 31st, 2016, employing Melior (Siemens Healthineers AG, Erlangen, Germany), a digital record and documentation system used by healthcare facilities in Sweden today. The surgical procedures were carried out by three independent maxillofacial surgeons (A, B, C) with ≥ 15 years of experience in orthognathic surgery. As part of the clinical routines established for orthognathic surgery at our unit, one gram of Tranexamic acid solution was administered intravenously at start of the operation.

Study population

Patients in the data base included in this study were: a) ≥ 18 years of age; b) had been treated with LFI, BSSO, or LFI + BSSO; c) the procedure had been carried out under hypotensive anesthesia, defined as 20% to 30% reduction of Mean Arterial Pressure (MAP). Patients were excluded: a) If the osteotomies were performed with additional genioplasty; or b) if the osteotomies were carried out for trauma, tumors, or cyst removals; c) smokers.

Data collection

All the procedures in this retrospective study were conducted at the Department of Oral and Maxillofacial Surgery by the two investigators (MH, KW). The search strategy of the investigators had been previously calibrated to efficiently extract information, limit missing data and thus maintain standardization in the study design. Specific information contained in the medical charts and databases for each patient included: i) Gender, age; ii) medications prescribed which could potentially affect bleeding time; iii) surgical procedures (LFI, BSSO, LFI + BSSO); iv) principal surgeon; v) irrigation (sodium chloride 0.9%) and the total volume of blood collected in the suction unit, vi) OT, defined as the time from first incision to complete wound closure. The information obtained under paragraph v) was subsequently used to calculate the intraoperative blood loss, defined as Estimated Blood Loss (EBL) in milliliter (mL) [2].

Objectives

The primary objective was:

- To evaluate the surgeon's impact on EBL, for the procedures combined (EBL – total) and for each surgical procedure separately (EBL – LFI; EBL – BSSO; EBL – LFI + BSSO).

The secondary objectives were:

- To investigate the difference in EBL between LFI, BSSO, LFI + BSSO.
- To investigate the OT for LFI, BSSO, and LFI + BSSO, respectively.

Statistical analysis

A power analysis (a priori) was performed for sample size estimation, based on data from a previous study [2] with similar measures. The effect size in this study was means (\bar{x} =271 mL); standard deviations (SD=149 mL). With an α -significance level =0.05 and power =0.8, the projected sample size needed with this effect size was n=179 (G*power version 3.1.9.4; University of Düsseldorf, Germany). Normality assumption was controlled using the Shapiro-Wilk test and a Gaussian distribution was confirmed for the tested variables. Descriptive data was presented with means (\bar{x}) and

Standard Deviations (SD). The primary, and secondary objectives were analyzed using one-way Analysis of Variance (ANOVA) followed by a Tukey correction for multiple comparisons. A p-value ≤ 0.05 was considered statistically significant. The analyses were employed using the IBM SPSS Statistics software package (IBM SPSS Statistics version 25, IBM Corp., Armonk, NY).

Ethical considerations

All the procedures in this study including research on identifiable human data were performed in accordance with the ethical principles established in the WMA Declaration of Helsinki (Fortaleza, October 2013). The study was also reviewed and approved by the clinical lead at the Department Oral and Maxillofacial Surgery, The Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden. An ethical approval by the Swedish Ethical Review Authority itself was not requested since this was a coded data base study. Identification numbers of all patients were encrypted and transformed using a random number sequence.

Results

In total, 208 case records of patients treated with orthognathic surgery were identified during this study, of whom 208 patients met the inclusion criteria. Following a systematic evaluation of the

Table 1: Summary of patient characteristics, osteotomies, and distribution of osteotomies among the three surgeons.

Patient Characteristics:				
Age	[years]	23	±	8
Gender	[F:M]	92	:	87
		51	%	49
Medications	[Y:N]	16	:	163
		9	%	91
Osteotomies:				
LFI	[Freq]	62	%	35
BSSO	[Freq]	44	%	25
LFI + BSSO	[Freq]	73	%	40
Total	[Freq]	179	%	100
Osteotomies/surgeon:				
Surgeon A:				
LFI	[Freq]	21	%	34
BSSO	[Freq]	5	%	11
LFI + BSSO	[Freq]	25	%	34
Total	[Freq]	51	%	28
Surgeon B:				
LFI	[Freq]	17	%	27
BSSO	[Freq]	24	%	55
LFI + BSSO	[Freq]	34	%	47
Total	[Freq]	75	%	42
Surgeon C:				
LFI	[Freq]	24	%	39
BSSO	[Freq]	15	%	34
LFI + BSSO	[Freq]	14	%	19
Total	[Freq]	53	%	30

LFI: Le Fort I; BSSO: Bilateral Sagittal Split Osteotomy; F: Female; M: Male; Freq: Frequency; Y: Yes; N: No

Table 2: Distribution of estimated blood loss among the entire study population, including all three types of osteotomies.

Estimated blood loss (mL):				
<100	[Freq]	8	%	4
100–500	[Freq]	135	%	75
501–899	[Freq]	26	%	15
≥ 900	[Freq]	10	%	6

Table 3: Analysis of the surgeons' impact on EBL – LFI; EBL – BSSO; and EBL – LFI + BSSO. Datasets are presented as mean ± SD. A p-value ≤ 0.05 was considered statistically significant.

Surgical procedures	Estimated blood loss (mL)			p – values
	Surgeon A	Surgeon B	Surgeon C	
LFI	330 ± 202	388 ± 268	307 ± 195	Ns
BSSO	220 ± 244	213 ± 120	161 ± 80	Ns
LFI + BSSO	489 ± 342	477 ± 280	389 ± 236	Ns

LFI: Le Fort I; BSSO: Bilateral Sagittal Split Osteotomy; EBL: Estimated Blood Loss

Table 4: The impact of the three surgical procedures, LFI; BSSO; and LFI + BSSO on EBL. Datasets are presented as mean ± SD. A p-value ≤ 0.05 was considered statistically significant.

Comparisons of the surgical procedures		Mean difference in EBL (mL)	p – values
LFI	BSSO	141	0.008
337 ± 218	LFI + BSSO	-127	0.006
BSSO	LFI	-141	0.008
196 ± 126	LFI + BSSO	-268	<0.001
LFI + BSSO	LFI	127	0.006
464 ± 294	BSSO	268	<0.001

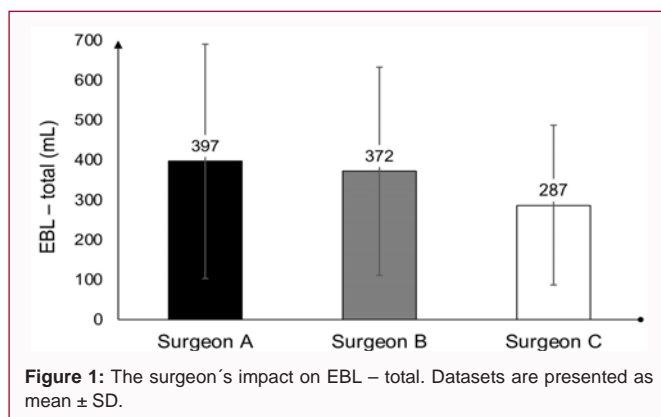
LFI: Le Fort I; BSSO: Bilateral Sagittal Split Osteotomy; EBL: Estimated Blood Loss

Table 5: Operative time for the three surgeons for each surgical procedure. Datasets are presented as mean ± SD. A p-value ≤ 0.05 was considered statistically significant.

Surgical procedures	Operative time (min)			p – values
	Surgeon A	Surgeon B	Surgeon C	
LFI	129 ± 58	103 ± 41	117 ± 30	Ns
BSSO	104 ± 18	81 ± 18	109 ± 17	0.031 ^X and <0.001 ^Y
LFI + BSSO	202 ± 71	172 ± 46	191 ± 24	Ns

LFI: Le Fort I; BSSO: Bilateral Sagittal Split Osteotomy; Ns: Not significant; ^X significant difference between surgeon B and A; ^Y significant difference between surgeon B and C

collected records, 29 out of the 208 included patients were excluded, and the remaining 179 patients were carried forward for the statistical analyses. The foremost reason for exclusion was osteotomy with additional genioplasty surgery, 59% (n=17/29). Other reasons for exclusion were osteotomy carried out to for trauma, tumors, or cysts, which together made up the remaining 41% (n=12/29) of the excluded patients. Among the 179 included patients 51% (n=92/179) were women and 49% (n=87/179) were men. The vast majority of the patients (91%; n=163/179) consumed no medications that were of significant importance from a bleeding point of view whereas 9% (n=16/179) were found to expend drugs that could affect the patient's bleeding time. These drugs were non-steroidal anti-inflammatory drugs or oral contraceptives. Bi-maxillary osteotomy, i.e., LFI + BSSO accounted for the highest proportion of the performed osteotomies (40%), followed by LFI (35%) and BSSO (25%), respectively. Table 1 provides a summary of the patient characteristics, osteotomies, and



distribution of osteotomies among the three surgeons. When the volume of irrigation was subtracted from the total volume of blood collected in the suction unit, mean EBL – total for the entire study population was 354 ± 258 mL. Nevertheless, it varied considerably ranging from 20 mL to 1500 mL per operation. For the majority of all patients 75% (n=135/179), an EBL between 100 mL to 500 mL was registered. The corresponding figures for the remaining 25% (n=44/179) of the patients were as follows: 4% (8/179) <100 mL; 15% (n=26/179) 501 mL to 899 mL; and 6% (n=10/179) ≥ 900 mL (Table 2). The surgeon's impact on EBL – total (mL; $\bar{x} \pm SD$) revealed the following numbers for surgeon A (397 ± 294); B (372 ± 261); and C (287 ± 200). However, no statistically significant difference was seen for EBL – total between the three surgeons (Figure 1). A similar outcome was observed when the corresponding comparison was carried out to compare the three surgeons for EBL – LFI; EBL – BSSO; and EBL – LFI + BSSO (Table 3). Furthermore, when mean EBL was calculated and subsequently compared between the three surgical procedures, the following figures were obtained (mL; $\bar{x} \pm SD$): LFI (337 ± 218); BSSO (196 ± 126); and LFI + BSSO (464 ± 294). The ANOVA showed a statistically significant difference in mean EBL for all comparisons, i.e., [LFI] and [BSSO] (p=0.008); [LFI] and [LFI + BSSO] (p=0.006); and [BSSO] and [LFI + BSSO] (p<0.001) (Table 4). Ultimately, when OT was calculated for the three surgeons [A–C] individually, for each of the surgical procedures (LFI; BSSO, LFI + BSSO), the following figures were obtained (min; $\bar{x} \pm SD$): LFI – [A] 129 ± 58, [B] 103 ± 41, [C] 117 ± 30; BSSO – [A] 104 ± 18, [B] 81 ± 18, [C] 109 ± 17; and LFI + BSSO – [A] 202 ± 71, [B] 172 ± 46, [C] 191 ± 24. A statistically significant difference was reached when OT was compared for BSSO between surgeon B and A (p=0.031) as well as surgeon B and C (p<0.001) (Table 5).

Discussion

The maxillofacial region is highly vascularized and even minor disruptions of the vessels in conjunctions with orthognathic surgery can jeopardize the blood supply to the actual region. Hence, seriously hamper the post-operative medical rehabilitation of the patient. In fact, severely damaged vessels constitute such a risk which may lead to a potentially fatal condition [10]. Over the past decades, a number of studies have been published investigating the potential association between patient-, or operator related factors and intraoperative blood loss [8,11]. Surprisingly, the impact of the surgeon on intraoperative blood loss has been studied only to a limited extent and needs to be further elucidated. This was the rationale for the conducting this four-year retrospective study. The ANOVA showed no statistically significant difference between the three surgeons for EBL – total or for

any of the surgical procedures separately. This was anticipated as the three surgeons were experienced and well-practiced on the procedures performed in this study. However, it is worth mentioning that even if differences exist between operators with regards to EBL, it may be difficult to quantify. This for several reasons: First, extensive bleeding seldom occurs in conjunction with orthognathic surgery [10]. In fact, it has been shown that intraoperative blood loss is comparably low even when surgical residents are compared to experienced surgeons [11]. Second, all patients were given tranexamic acid prior to the surgical interventions, which is well-known to reduce the risk for bleeding [12,13] and improve the quality of the surgical field [13-15]. Third, the numbers of osteotomies were unequally distributed among the operators which may have influenced the outcome of this study. The latter however can be explained by the nature of retrospective studies where uneven cohorts may be encountered. Prospective, randomized studies where the number of patients and procedures are equally distributed among the operators are therefore warranted. When the secondary objective (ii-a) was analyzed, a statistically significant difference was found for EBL between all the surgical procedures. The maxillary osteotomies were bleeding significantly more as compared to the mandibular counterparts. This can be attributed to the fact that the maxilla encompasses a higher vascular density. Hence, entails a greater risk for bleeding [2]. In addition, some maxillary osteotomies were reported to bleed excessively, mainly due to aberrant anatomy, which had resulted in perforation of larger vessels. Some cases also reported a significant bleeding from the nasal mucosa during down fracturing-, or posterior repositioning of the maxilla. Bi-maxillary osteotomy as a group showed the highest EBL of the three surgical interventions, which is not surprising since it is the sum of both procedures. Taken together our findings seem reasonable and they are in accordance with previously published studies [2,6]. As for the secondary objective (ii-b), a statistically significant difference was seen when OT was compared for BSSO between surgeon B and A as well as surgeon B and C. However, although a statistically significant was observed, the clinical relevance remains questionable. Most likely, the additional time of approximately 25 min for operator A and C as compared to B will not lead to an increased EBL in clinical settings. This is supported by a study in which surgical residents required longer OT for their osteotomies as compared to the experienced surgeons, yet the EBL did not vary significantly [11].

Conclusion

Intraoperative blood loss during orthognathic surgery is not operator dependent when comparing experienced surgeons. However, both surgical procedure per se and operative time seem to be of relevance.

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