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VERTICAL AND HORIZONTAL STABILITY FOLLOWING LE FORT I OSTEOTOMY WITHOUT BONE GRAFT

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ABSTRACT

Objectives: the study aimed to evaluate the vertical and horizontal stability following Le Fort I osteotomy without using any bone graft in patients with maxillary advancement up to 6 mm alone or combined with vertical repositioning.

Patients and methods: patients referred for one piece Le Fort I osteotomy with or without other orthognathic procedures were included in this study. In all surgeries, the maxilla was fixed using titanium plates and no bone graft was used in any of the patients. Suspension wires were fixed to be used for IMF with elastics postoperatively. Lateral cephalometric X-rays were taken 1 week after the surgery (T1), and 1 year after the surgery (T2), these X-rays were used to evaluate the postoperative stability using the SNA angle, maxillary depth angle, palatal plane angle, and maxillary height angle to evaluate changes in the horizontal and vertical direction.

Results: The lateral cephalometric analysis for relapse in the anteroposterior direction showed that only 6 patients out of 18 (33.3%) encountered a relapse of more than 2° in SNA angle and 5 (27.7%) in the maxillary depth angle measurements. Yet in between those patients there was only one (5.5%) out of 18 patients had only maxillary advancement without vertical repositioning. The results of the maxillary height and palatal plane angles showed that all the changes of more than 2° in the vertical direction were in the elongation group (3 patients out of four) (75%) using the palatal plane angle while it was only 1 patient (25%) using the maxillary height angle evaluation. Conclusion: within the limitation of the present study (small sample number especially in the patients with vertical repositioning) ; the study suggests that the use of bone graft can be avoided in maxillary advancement movement up to 6 mm anterior repositioning even this was combined with superior repositioning. Moreover the study recommends the use of bone graft in cases of anterior maxillary advancement with inferior repositioning of the maxilla.

KEY WORDS: Orthognathic surgery stability, Le Fort I osteotomy, bone graft

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INTRODUCTION

In the last 60 years Le Fort I osteotomy and its variations became a regular operation in orthognathic surgeries as a result of its ability to adapt to many functions and many sided movements. Such as anteroposterior maxillary hypoplasia, vertical maxillary excess or deficiency, anterior open bite, and transverse discrepancy. ***(Landes CA, 2006)***. But, because the main aim of orthognathic surgery is to restore normal function, improve facial esthetics, and keep these results for the whole life, postoperative relapse is so considered one of the most troublesome problems after orthognathic surgery because it compromises all the already achieved desired operative results. ***(Hirano A 2001)***. Multifactor have been suggested to have an influence on stability after Le Fort I osteotomy including type of fixation used, amount and direction of movement, and the use of bone grafts. ***(Egbert M, et al. 1995), (Waite PD et al. 1996) (Dowling AP et al. 2005)***.

In order to overcome the influence of the previously mentioned factors on relapse incidence after orthognathic surgeries, plate-fixation and bone grafting to the osteotomy gap have therefore been recommended for better stability especially after maxillary advancements. ***(Adlam et al., 1989; Posnick and Ewing, 1990) (Posnick and Taylor, 1994). (Landes CA, 2006).*** Bone graft placement aimed to have bone-to-bone contact, this physical contact will minimize the chance of relapse by giving a physical barrier to the movement and preventing the surrounding soft tissues from being entrapped in-between the bony segments preventing complete bony healing more over the osteogenic, osteoinductive and osteoconductive effects of the bone graft material. While the ideal material would be an autogenous graft, yet, this increases the surgical time, discomfort, scaring at the donner site , movement restriction when using one of the extremities as a donner site, and risk of infection. ***(Rosen HM, Ackerman JL 1991)***, ***(Eser C et al., 2015)***. These disadvantages related to the use of autogenous bone grafts encouraged the researchers to try not using a bone graft or use other bone substitutes rather the autogenous one. ***(Rosen HM 1989) (Rosen HM, Ackerman JL1991) (Ayliffe et al., 1995) (Waite PD et al. 1996) (Hirano A 2001). (Borstlap WA et al., 2004) (Eser C et al. 2015)***.

There have been numerous studies on long term stability or relapse after maxillary advancement surgery by Le Fort I osteotomy. However, the results and conclusions of these studies varied and sometimes even contradict and interfere to each other. Some of these studies stated that when the maxillary advancement is greater than 4 mm, the resultant bone gap in the lateral wall of maxillary sinus should be grafted, yet it is still not established what gap size or amount of advancement that should be grafted. ***(Louis PJ et al. 1993) (Waite PD et al. 1996) (Bothur S et al. 1998) (Eser C et al. 2015).*** Therefore the present study aimed to evaluate the vertical and horizontal stability following Le Fort I osteotomy without using any bone graft in patients with maxillary advancement up to 6 mm alone or combined with vertical repositioning.

PATIENTS AND METHODS

Participants included in the study were referred for orthognathic surgery treatment to the Department of Oral and Maxillofacial Surgery, College of Dentistry, King Saud University, Saudi Arabia in the time period of September 2009 to March 2014. All surgeries were conducted by the same team and the same surgeon (the author). Inclusion criteria were patients with a surgical treatment plan including one piece Le Fort I osteotomy with maxillary advancement up to 6 mm (with or without other orthognathic surgery procedure) and their treatment plans were postulated , conducted, and followed by the same orthodontic-orthognathic surgery team in the dental college, king Saud university. Exclusion

criteria were patients with a treatment plan of Le Fort II, III, or segmental maxillary osteotomy and Patients refused to share in the study. Also, intraoperatively patients whom needed amount of advancement more than 6 mm were excluded from the study.

In all surgeries, a typical Le Fort I osteotomy was performed and the maxilla was fixed using titanium osteosynthesis. Titanium-osteosynthesis was accomplished with the use of four pieces of 2-mm (2 plates at each side). The plates were plied adapted to bone for passive fit and placed at paranasal areas and zygomatic buttress bilaterally, and fixed with 6-mm length screws (4 screws for each plate). A suspension wire were fixed in a surgically created hole in the lateral nasal bone bilaterally above the level of the horizontal bony cut of the Le Fort I osteotomy. The wire was partially twisted and hoked facing upward putting in consideration that it should appear intraorally after suturing. And the same was done with two other wires fixed to the mandibular canine region with 2 mm screws bilaterally but the wires were hoked facing downward. These wires were used for IMF with elastic bands for 6 weeks postoperatively. (Figure 1) Other elastics were used to counteract the relapse direction in all patients using the surgical hooks fixed on the orthodontic wires, adjustment of the elastic band directions depended on each case individually. After releasing the IMF elastics, the suspension wires were left in their places passively for at least extra 6 weeks, to be sure that we do not need them any more to counteract any undesired postoperative movement in the early postoperative period.

Fig. (1) Showing the suspension wires used for IMF using elastics

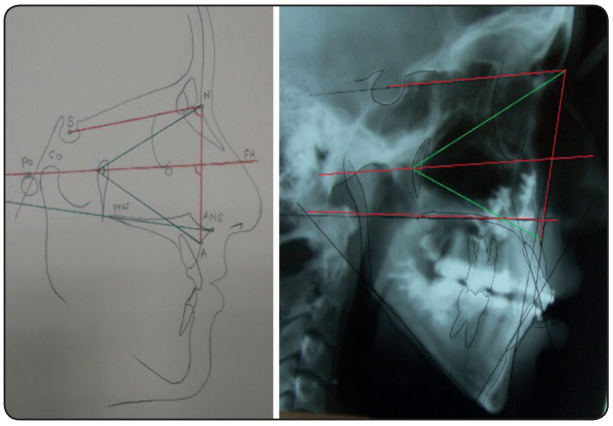

Fig. (2) Showing the angles used to check the postoperative stability in the anteroposterior and vertical directions.

Lateral cephalometric X-rays were taken 1week before, 1 week after the surgery (T1), and 1 year after the surgery (T2) with a Planmeca Proline XC x-ray unit (Planmeca Inc., Helsinki, Finland). Using the Dolphin imaging 11.7 (Dolphin Imaging and Management Solutions, Chatsworth, Calif., USA) computer program, the X-rays were used to evaluate the postoperative stability and determine the amount of relapse, the cephalometric measurements used to measure the possible horizontal postoperative changes were SNA angle, and maxillary depth angle. While changes in the vertical direction were evaluated using the palatal plane angle, and maxillary height angle. (Figure 2)

The purpose of these measurements was angularly measure possible vertical and horizontal postoperative changes, over time (the follow-up time), and relate them to the nonuse of bone grafts. These collected measurements were analyzed using SPSS (version 22, IBM Chicago, IL, USA) Differences between measurements were statistically analyzed using paired *t* test for means, at a level of significance ($p < 0.05$).

RESULTS

The total number of patients who fit the inclusion criteria and participated in the study was 18 patients, 13 female (72.2%) and 5 male (27.8%). The demographic data of the patients, type of surgery, and maxillary repositioning range and direction are shown in (Table 1.)

The lateral cephalometric analysis for relapse in the anteroposterior direction showed the following results; in all the 18 patients. Only 6 patients (33.3%) showed a relapse of more than 2° in SNA angle and 5 (27.7%) in the maxillary depth angle measurements. Yet in between those patients there was only one (5.5%) out of 18 patients had only maxillary advancement while the others had combination of advancement with vertical repositioning. All the four patients underwent maxillary repositioning (elongation) showed more than 2° change in the last radiographic evaluation in by the SNA angle evaluation ,while only 3 of them (75%) showed this change in the Maxillary depth angles. Regarding the other 3 patients of vertical repositioning (impaction), only one of them (33.3%) showed more than 2° change in the last radiographic evaluation in both the SNA and Maxillary depth angle measurements. The statistical analysis of the data collected from the SNA and Maxillary depth angles showed a significant relapse in between all the 18 patients including the 11 patients with pure advancement (SNA *p= 0.00088*, MDA *p= 0.000024*), patients with a combined movement (advancement and vertical repositioning) (SNA *p= 0.00034*, MDA *p= 0.000078*), with the highest relapse with the patients with down maxillary elongation (Table 2) and (Figure 3&4)

On the other hand, the results of lateral cephalometric analysis using the maxillary height and palatal plane angles to detect the changes in the vertical direction, showed that all the changes of more than 2° were in the elongation group (3 patients out of four) (75%) using the palatal plane

TABLE (1) Showing the demographic data of the patients, type of surgery, and maxillary repositioning range and direction

		Age	Surgical procedure		Type of maxillary movement					
					Horizontal advancement		Vertical repositioning			
							Maxillary impaction		Maxillary elongation	
			Le Fort I	Bimax-illary	No. of patients	Range of movement	No. of patients	Range of movement	No. of patients	Range of movement
Gender	Male	19:30 (mean24.8)	1 (5.5%)	4 (22.2%)	5 (27.8%)	4:5 mm Mean (4.4 mm)	0 (0%)	0	2 (11.1%)	3 mm Mean (3 mm)
	Female	19: 27 (mean22.3)	3 (16.7%)	10 (55.5%)	13 (72.2%)	4:6 mm Mean (4.7mm)	3 (16.7%)	2:4 mm Mean (3.3 mm)	2 (11.1%)	2:3 mm Mean (2.5mm)
Total	18	19: 30 (mean23)	4 (22.2%)	14 (77.8%)	18 (100%)	4:6 mm Mean (4.55mm)	3 (16.7%)	2:4 mm Mean (3.3mm)	4 (22.2%)	2:3 mm Mean(2.75mm)
							Total 7 (38.9%)			

angle while it was only 1 patient (25%) using the maxillary height angle evaluation. The statistical analysis of the data collected from the PPA and Maxillary height angles showed a nonsignificant relapse regarding the vertical direction in between all the 18 patients including the 11 patients with pure advancement (PPA p= 0.34, MHA p= 0.34), yet, when the data of the pure advancement 11 patients were excluded the t test showed a significant relapse in the group of patients with a combined movement (advancement and vertical repositioning) (PPA p= 0.017, MHA p= 0.015), with the highest relapse with the patients with down maxillary elongation (Table 3) and (Figure 5&6).

TABLE (2) Showing the statistical analysis of the cephalometric measurements for relapse in the anteroposterior direction

	no. of patients (out of 18) showed relapse more than 2°			paired t test statistical analysis		
	patients with only advancement (11 patient)	patients with a combined advancement with vertical repositioning (7 patients)		t1-t2 results of all the 18 patients	t1-t2 results of the only pure advancement patients (11 patients)	t1-t2 results of the combined advancement and vertical repositioning movement (7 patients)
		maxillary down elongation (4 patients)	maxillary impaction (3 patients)			
SNA	1	4	1	Mean 1.89 SD 1.09 *P* 0.000018	1.27 0.86 0.00088	2.85 0.64 0.00034
MDA	1	3	1	Mean 1.67 SD 1.15 *P* 0.000024	1.18 0.57 0.00069	2.71 0.69 0.000078

TABLE (3) Showing the statistical analysis of the cephalometric measurements for relapse in the vertical direction

	no. of patients (out of 18) showed relapse more than 2°			paired t test statistical analysis		
	patients with only advancement (11 patient)	patients with a combined advancement with vertical repositioning (7 patients)		T1-T2 results of all the 18 patients	T1-T2 results of the only pure advancement patients (11 patients)	T1-T2 results of the combined advancement and vertical repositioning movement (7 patients)
		maxillary down elongation (4 patients)	maxillary impaction (3 patients)			
PPA	0	3	0	Mean 0.67 SD 1.2 *P* 0.052	0.09 0.28 0.34	1.71 1.27 0.017
MHA	0	1		Mean 0.55 SD 1.01 *P* 0.057	0.09 0.28 0.34	1.42 1.05 0.015

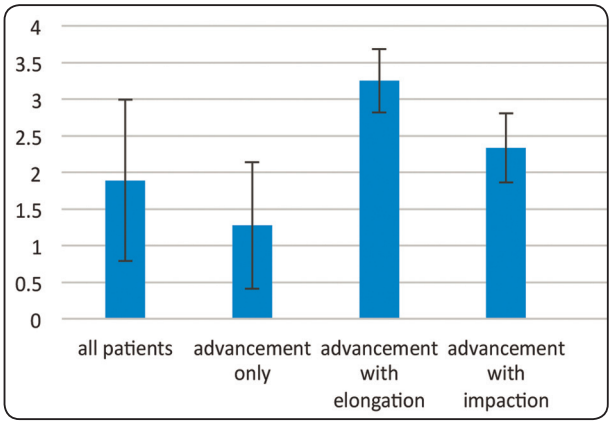

Fig. (3) Showing mean values of the changes in the SNA angle measurments

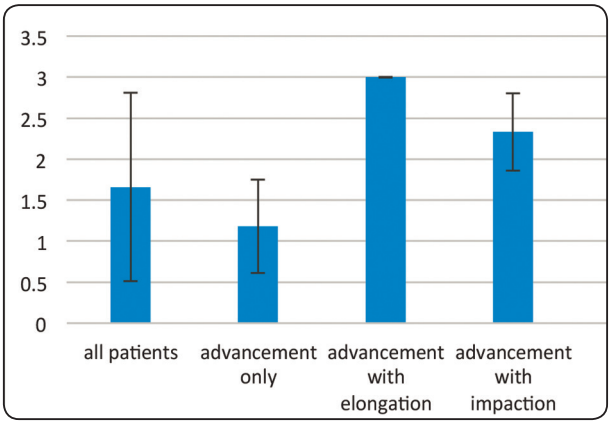

Fig. (4) Showing mean value of the changes in the Maxillary Depth Angle measurments

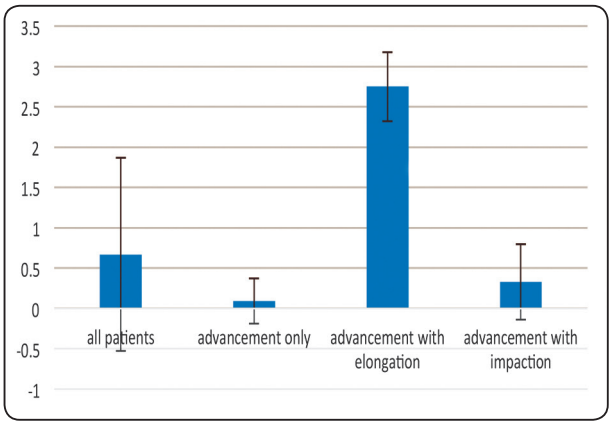

Fig. (5) Showing mean values of the changes in the Palatal Plane Angle measurments

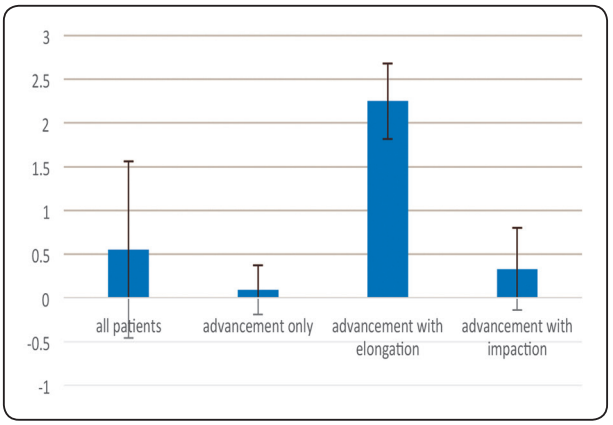

Fig. (6) Showing the mean values of the changes in the maxillary height angle measurments

Fig. (7) 24 year old male patient, treated with bimaxillary orthognathic surgery without the use of bone graft. Raw labeled with (A) showing the preoperative pictures while raw labeled (B) showing the corresponding 1 year postoperative ones.

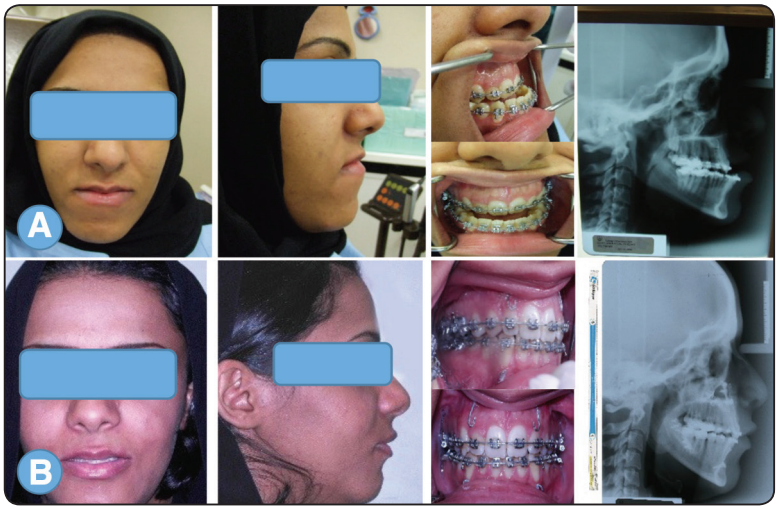

Fig. (8) 22 year old female patient, treated with bimaxillary orthognathic surgery without the use of bone graft. Raw labeled with (A) showing the preoperative pictures while raw labeled (B) showing the corresponding 1 year postoperative ones.

DISCUSSION

Despite the advances in the surgical field in general and in orthognathic surgery in particular still the achievement of three-dimensional stability following orthognathic surgery continues to be a major challenge in the postsurgical period.This is why the postoperative stability after orthognathic surgery especially after Le Fort I osteotomy had and still under studies seeking for the factors affecting this stability and how to avoid or at least how to predict and decrease its incidence. (Dowling AP et al. 2005) (De Menezes et al. 2013) (Eser C et al. 2015).

In the present study we used in our definition of relapse the definition of Proffit et al., as they defined relapse to be a retrogression of distances and angles by >2 mm and >2 ° toward their preoperative baseline values. (Profitt et al. 2000)(Profitt et. al 2007) (De Haan et al. 2013). According to this definition; although the present study results of patients with only maxillary advancement without vertical repositioning showed a statistically significant relapse in SNA and MDA (p 0.0008 and 0.0007) yet, only one patient out of 11 patients (9%) showed more than 2° relapse in both of the SNA and MDA angles. Comparing these results with the results of Lands and Ballon 2006, and Dowling et al., 2005; as they had nearly similar average of advancement amount, our results showed a little bit more stability as the relapse percentang reported by Lands and Ballon was 10% to 26% depending on the plating system used (titanium versus resorbable plates) in their patients using no bone graft material. While the relapse percentage reported by Dowling et al., was 14%. The author of the present study refer the little bit more stability in the present study to the use of the suspension wires that act to sandwich the previously down fractured maxilla between the still stable non fractured part of the maxilla and mandible.

While comparing our study results with other studies used autogenous bone grafts the present study results appeared to be higher with about 2% , as the anteroposterior relapse percentage using autogenous bone graft reduced to 6% with ***Egbert et al., 1995,*** 7% with Waite et al., 1996, and 6.8% with ***Eser et al., 2015.*** But when the treatment plane include only Le Fort I osteotomy without mandibular BSSO setback where we can use the bone removed from the mandibular surgery or in case of mandibular advancement procedure, the author suggest to balance between the suspected relapse amount and the suspected drawbacks of harvesting autogenous bone graft reported in a variety of previous studies which include adding another operative procedure at

the donner site which will elongate operation time, increase the postoperative pain, bleeding, scaring from the donner site, restrict the movement (in case of iliac crest graft), and prolong hospital stay time, and even late instability that may result from graft resorption.***(Rosen HM 1989) (Rosen HM, AND Ackerman JL 1991) (Eser et al., 2015)***

On the other hand, our results appeared to be comparable to the studies used other bone graft material rather than the autogenous bone to avoid its drawbacks. In these studies the amount of anteroposterior relapse reported by ***Mehra et al., 2002*** whom used hydroxyapatite blocks as a graft material was 9%, while this percentage was 6.9% with ***Eser et al., 2015*** as they used xenogeneic spongiotic bone material. Although the use of other bone substitutes instead of the autogenous bone graft seems to avoid the disadvantages of the last one, yet they still have their own complications including immunogenic reactions and higher costs. ***(Rosen HM 1989) (Rosen HM, AND Ackerman JL 1991) (Kramer FJ et al., 2004)***

Applying the same relapse definition of Proffit et al. on the vertical relapse results of the present study; although the statistical analysis of the whole 18 patients regarding vertical relapse showed a nonsignificant changes either in PPA, or in MHA (p= 0.0524, P= 0.0579) but could be explained by the including the data of the 11 patients with only advancement movement. But when the data of only the 7 patients treated with maxillary advancement with vertical repositioning were analyzed the statistical analysis showed a highly significant relapse in both PPA, and MHA angles (p=0.017. p=0.015). Explaining the results in a form of percentage showed that the relapse of the group of patients underwent maxillary repositioning (7 patients) was from 14% to 43% using the MDA, and PPA angles respectively. These results are comparable to that of ***Eser et al., 2015*** with the autogenous bone as they reported 16.6% relapse in the vertical direction and 10.5% with the use of xenogeneic spongiotic bone graft material.

None of the patients underwent maxillary impaction (3 patients) showed relapse more than 2° which come in agreement with a variety of reviews and researches that concluded that the maxillary impaction procedure is the most stable orthognathic procedure with a stability incidence more than 90%. ***(Bailey et al. 2004) (Profit WR et al. 1996) (Profit WR et al. 2000)***. While the results of the 4 patients underwent maxillary elongation with maxillary advancement showed 25%:75 % relapse using the MHA and PPA angle respectively. Although these results are higher than that reported by ***Lands 2006*** who confirmed a relapse of 14% without bone graft and with the results of ***Waiet et al., 1996*** whom stated a relapse rate of 10.5% to 16.6% using bone grafts, yet our results still supported by the of a variety of studies stated that the maxillary elongation procedure is an unstable one and considered the highest risk for relapse in orthognathic surgery. ***(Profit et al., 2000) (Baker et al., 1992) (Eser et al., 2015)***. In the present study, the author think that the use of the PPA was more accurate than the MHAin recording the changes in the vertical direction. This is due to in the PPA the angulation of the whole length of the palate was evaluated, so any change in the anterior or the posterior part of the maxilla was recorded. While in the MHA the change depend only on the anterior part of the maxilla, and this can explain the differences in the recorded changes between the two angles in the study.

In other studies the percentage of relapse in patients with maxillary inferior positioning ranged from 0.4% to 48% percent in ***Gurstein 1998*** study using bone grafts, to a 100% relapse in all the study groups of ***Ellis et al., 1989*** study including the groups of rigid fixation and bone graft. The author of the present study think that the study results and its comparison to the previously mentioned studies can direct the reader again to try to make balance between the amount and direction of movement needed and the suspected percentage of relapse with the potential disadvantages of using bone graft.

CONCLUSION

Within the limitation of the present study (small sample number especially in the patients with vertical repositioning)

- The study suggests that the use of bone graft can be avoided in maxillary advancement movement up to 6 mm anterior repositioning even if this was combined with superior repositioning
- The study recommends the use of bone graft in cases of anterior maxillary advancement when combined with inferior repositioning of the maxilla regardless the amount of advancement and gap size

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