Efficacy and Accuracy of Virtual Surgical Planning in Mandible Reconstruction Using Fibula Free Flap: A Comparative Study of Three Different Methods

Albogami Nawaf Hmood G

The Graduate School
Yonsei University
Department of Dentistry

Efficacy and Accuracy of Virtual Surgical Planning in Mandible Reconstruction Using Fibula Free Flap: A Comparative Study of Three Different Methods

Albogami Nawaf Hmood G

The Graduate School
Yonsei University
Department of Dentistry

Efficacy and Accuracy of Virtual Surgical Planning in Mandible Reconstruction Using Fibula Free Flap: A Comparative Study of Three Different Methods

Directed by professor Hyung Jun Kim

A Master's Thesis Submitted to the Department of Dentistry
and the Graduate School of Yonsei University
in partial fulfillment of the requirements
for the degree of M.S in Dental Science.

Albogami Nawaf Hmood G

November 2022

This certifies that the master's thesis of Albogami Nawaf Hmood G
is approved.

Thesis Supervisor : [Hyung Jun Kim]

Thesis Committee Member : [Woong Nam]

Thesis Committee Member : [Dongwook Kim]

The Graduate School
Yonsei University
November 2022

ACKNOWLEDGEMENTS

Words cannot express my gratitude to my professor Hyung Jun Kim. I could not have undertaken this journey without him. Professor Hyung Jun Kim generously provided knowledge and expertise to everyone and I personally learned a lot from him in all aspects of life. Additionally, this endeavor would not have been possible without the generous support from Professor Dongwook and Dr. Hyounmmin Kim. I am also grateful to my family, especially my parents, wife, and children. Their belief in me has kept my spirits and motivation high during this process.

Table of Contents

List of Figures

List of Tables

Abstract

Computer-assisted surgery (CAS) in mandibular reconstruction has proven its value regarding more predictable postoperative results. In this study we will report and compare the accuracy and efficacy of a computer-assisted surgical guide in mandibular reconstruction using three different methods; 1st which uses reciprocating saw (motor-driven) and fibula guide but without a mandible fixation guide, while 2nd is using a sagittal saw (pneumatic powered) with a mandible fixation guide and fibula guide, and 3rd which uses the sagittal saw and predrilled hole at fibula guide without mandible fixation guide. Retrospective study in one center from 2019 to 2022 for patients who underwent mandibular reconstruction using computer-assisted surgery (CAS) with the paired Brown classification for mandibular defect [27]. Patient demographic data, diagnosis, presence or absence of adjuvant therapy, type of plates, number of osteotomies, operative time, ischemic time, reconstruction time, length of the hospital stays and complications compared, and pre and postoperative STL be used to evaluate the structural accuracy following van Baar GJC, guidelines [33]. Nine patients were included in the study with 3 for each method, in all of the cases the flap survived, method 3 which uses the sagittal saw and predrilled hole at fibula guide without mandible fixation guide showed the lowest ischemic time. Although the overall surgical accuracy was good, a few outliers were observed in our study. In conclusion CAS using the sagittal saw and predrilled hole at fibula guide is more convenient for the operator and beneficial for the patient in terms of less ischemic time.

Overall surgical accuracy was comparable for all the methods however method 1 which uses reciprocating saw and fibula guide but without a mandible fixation guide was the least accurate. Further studies recommended with implementation of higher number of patients as in this study the number of the patients is limited.

Key words: Mandible reconstruction, Computer assisted surgery, Fibula free flap, Fibula cutting guide.

INTRODUCTION

The Fibula Free Flap (FFF), which Hidalgo initially described in 1988, is now regarded as a cornerstone in the reconstruction of complex mandibular defects [1]. Many previous studies demonstrated that this method produces satisfactory long-term functional and esthetic outcomes [2–6]. The process is time-consuming and technically demanding. It takes precise positioning and contouring of harvested fibular segments to restore the three-dimensional (3D) structure of the mandible, which is capable of normal occlusion, speaking, and mastication. Unfortunately, traditional methods of shaping, inserting, and fixing bone pieces depend heavily on the surgeon's experience and are sometimes inaccurate [7–9].

Virtual surgical planning (VSP) has gained acceptance as a dependable technique to facilitate mandibular reconstruction with FFF in recent years [10-18]. Initially, this technology was employed to produce stereo lithic models of the mandible and fibula using preoperative CT scans, which were then used to mimic the reconstruction process and/or serve as anatomical guides during the proper operation [7,13,19]. However, computer-assisted surgery's (CAS) approach has changed over time. Currently, a virtual plan is created first for mandibular resection and reconstruction, and then the procedure is carried out with the help of patient-specific osteotomy guides and prebent plates [9–18,20–23]. The surgeon can then harvest an osseous flap, the ideal characteristics of which, such as localization, size, and angulation, have already been determined on a virtual model. This makes it easier to create the new mandible with the necessary properties by allowing for accurate positioning and approximation of the fibular segments [8,12,13,20-24]. Previous research showed that using the VSP increased the mandibular reconstruction's accuracy and effectiveness and decreased operating time and overall treatment costs [8–11, 13, 17, 24–26].

In this study we will report and compare the accuracy and efficacy of a computer-assisted surgical guide in mandibular reconstruction using three different methods; 1st which uses a reciprocating saw (motor-driven), without a mandible fixation guide, while 2nd is using a sagittal saw (pneumatic powered), with mandible fixation guide and fibula guide, and 3rd which uses the sagittal saw and a predrilled hole at fibula guide without mandibular fixation guide.

Objectives

The aim of the study is to determine the degree of accuracy for the three different methods and to confirm the benefits in the sake of reducing the surgery time and increasing the success rate of the surgical maneuvers.

MATERIALS AND METHODS

A retrospective study in one center from 2019 to 2022 for patients who underwent mandibular reconstruction using computer-assisted surgery (CAS) with paired Brown classification for the mandibular defect. [27]. Patient demographic data, consent, diagnosis, presence or absence of adjuvant therapy, type of plates, number of osteotomies, operative time, ischemic time, reconstruction time, length of the hospital stays, and complications compared, and pre and postoperative CT used to evaluate the structural accuracy following van Baar GJC, guidelines [33].

Inclusion and exclusion criteria:

A total of 9 patients out of 57 treated with mandible reconstruction using fibula free flap were included in this study, the patients included in this study are according to brown mandibular resections classifications: class I, class IIC and class III and we excluded any other classes, also patients falling under one of the three methods with available pre- and post-operation virtual planning were included. (Table1)

Table 1: Inclusion and exclusion criteria

Inclusion	**Exclusion**
Available pre and post op CT using identical machine and scanner	Patient with different CT scan or machine for example: CT for RT plan were excluded
Brown mandibular resections classifications: class I, class IIC and class III	We excluded other Brown classifications
Patient with available intraoperative pictures	Patient with missing or distorted pictures were excluded
Patient with operation time record for both: total op, ischemic time, and reconstruction time.	Patients with missing operation time record were excluded.

3D model preparation

The acquired DICOM data of relevant CT neck and CT angiography for lower extremity was exported. DICOM data was imported into the Mimics software. Radiological images were evaluated, and 3D models were calculated by using the software. Virtual planning for the osteotomy and cutting guide was done after approval from the main surgeon. The model was then exported as an STL file for further processing and manufacturing of the guides. In addition, the DICOM file of the patients was exported postoperatively to compare with pre-op STL later. (figure1)

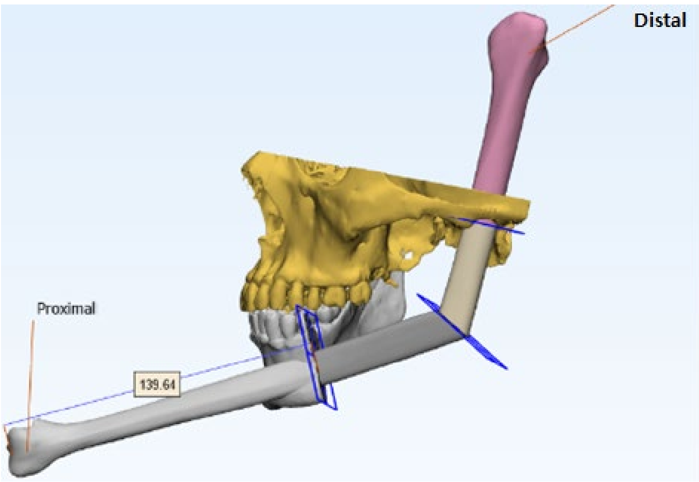


Figure 1. 3D virtual planning showing the estimated location, length, and osteotomy for mandible reconstruction

Operative techniques

Operations were done using patient-specific surgical guides. Then mandibular resection and the osteotomy of the donor's bone were directed by surgical guides. for method one we used the reciprocating saw with the fibula guide (figure 2), in method 2 we used the sagittal saw with a positioning device (mandibular fixation guide). (Figure 3). while in method 3 we used the sagittal saw with predrilled holes at the fibula (figure 4) the positions and directions of the screws in the bone were determined in the laboratory and then transferred to the operation room.

Following bone graft harvest, surgical guides helped with segmentation and screw hole drilling. Bone grafts were then fixed to the patient-specific plate to create the bone-plate complex. After that, bone graft segments were transferred to defect sites and fixed with patient-specific surgical reconstruction plates or occasionally with mini plates.

Method 1

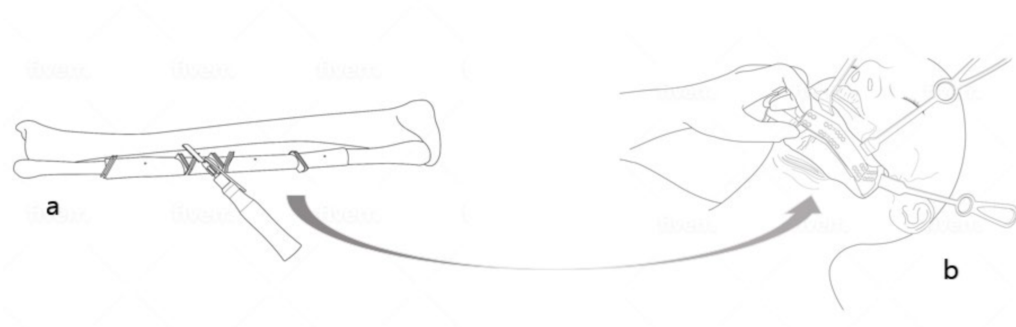


Figure 2: Method 1 which uses (a) reciprocating saw to cut through fibula guide. (b) fibula bone located at the defect site

Method 2

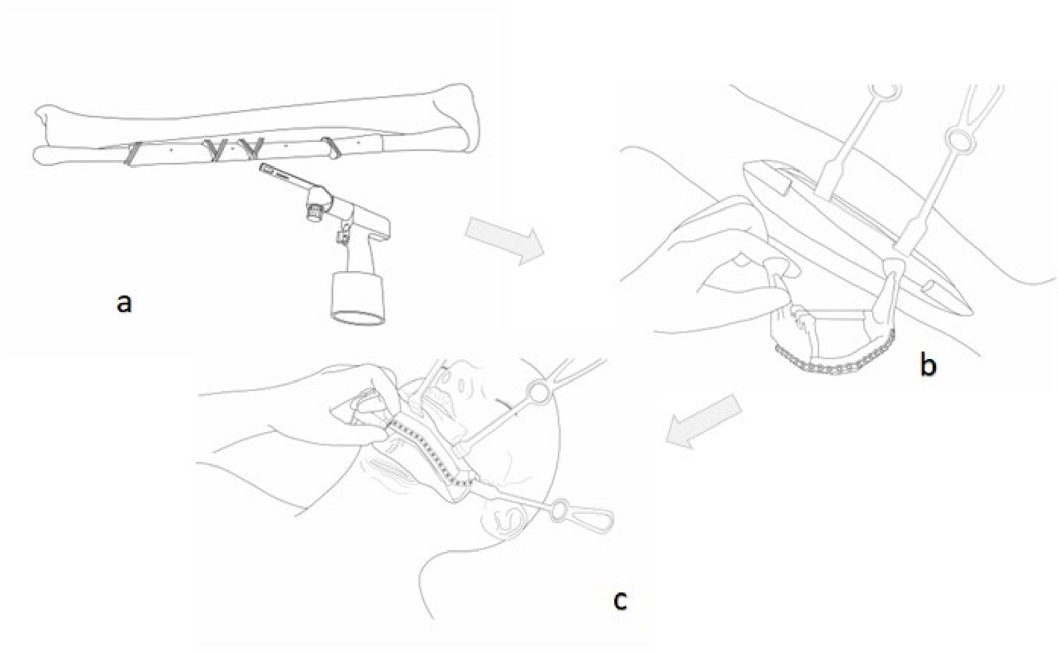


Figure 3: method 2 which uses (a) sagittal saw to cut through fibula guide. (b)mandible fixation guide which is a patient specific custom-made mandible acting as a fixation guide, (c) fibula bone located at the defect site

Method 3

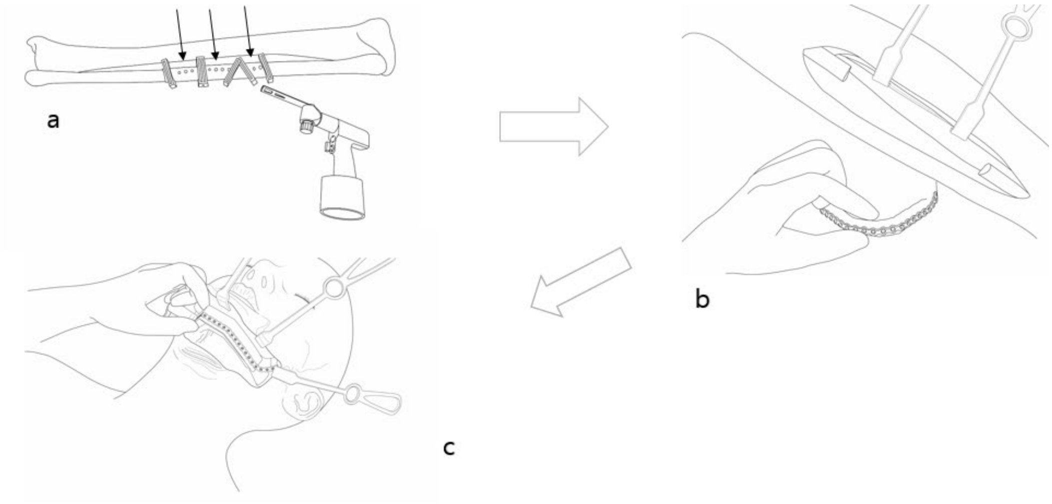
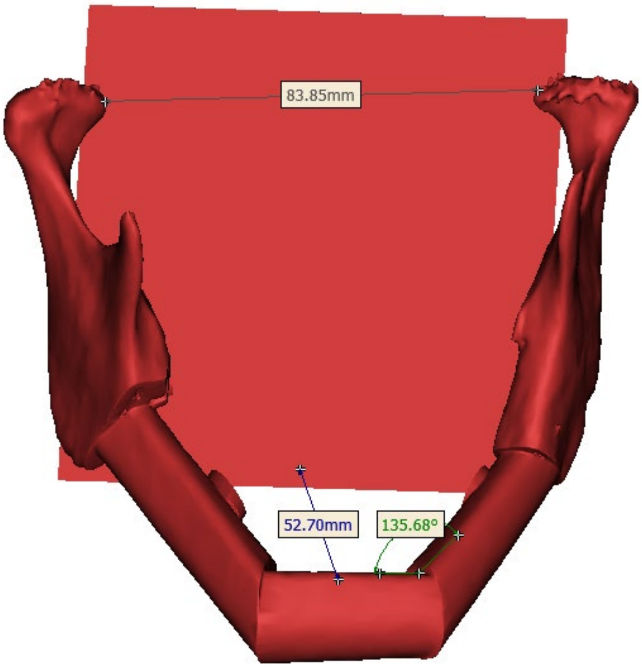


Figure 4: method 3 which uses (a) sagittal saw to cut through fibula guide with predrilled holes. (b)bone graft fixed to the patient-specific plate to create the bone-plate complex., (c) fibula bone located at the defect site.

Anatomical measurement

We used various measures to evaluate the integral mandible's distance and angulation deviations. Both pre- and post-op STL files were imported into the mimics software again. The STL models were marked with defined points for distance and angle measurements. The resulting values were collected and used for further statistical analysis. The mandibular width, the anterior-posterior length, and the angle between segments were measured. Condylar distances were measured Additionally, the distance from the condyle's surface to the gnathion (Gn) the most caudal point of the mandible symphysis in the median-sagittal plane was measured also the angle between segment were measured too. (Figure 5)



(Figure 5) Anatomical measurement of one of the pre op STL files, to be compared later with the post op STL file, here we measured both the mandibular width, anterior-posterior length, and the angle between segments using mimics software.

Cloud Compare:

The virtually planned model was superimposed with a post-op model. A color map was used to show the difference between the positions that were virtually intended and those that were really accomplished. The green color indicate that the deviation was less than 1.0 mm. while red color indicates 4 mm difference or more and blue mean -3 or less (figure 6)

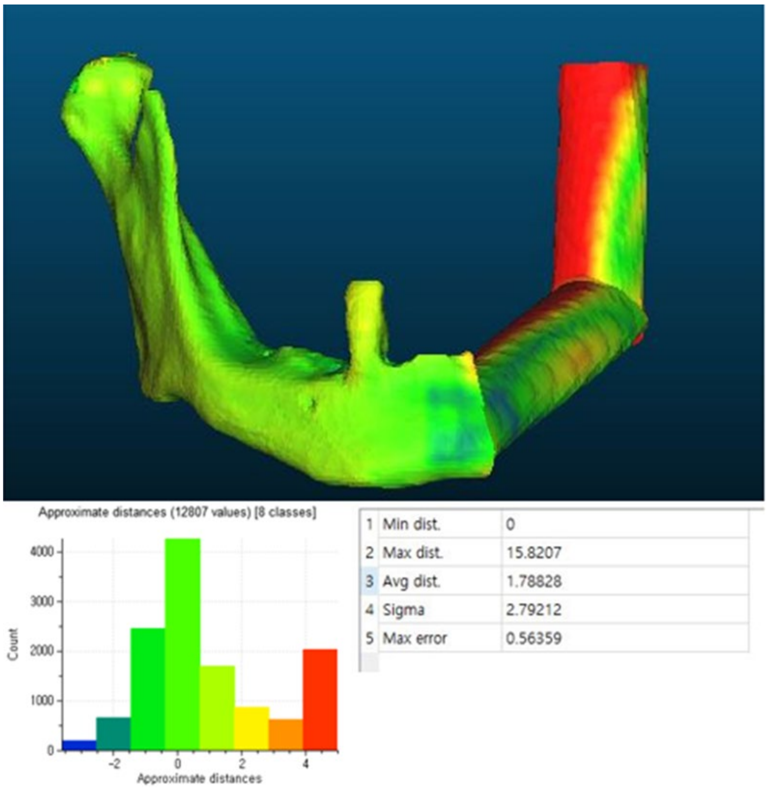


Figure 6 superimposition of both pre & post STL model using Cloud Compare software, and histogram representing the distance variation with green which indicate that the deviation was less than 1.0 mm. while red color indicates 4 mm difference or more and blue indicate -3 or less.

Statistical analysis tool: SPSS.

RESULTS

Of the total nine subjects, two third (n=6, 66.7%) were male. The mean (sd) age of the subject was 49.4 (14.0) years ranging from 29-80 years (table2). CT scans were used in all cases.

The patients' characteristics are shown in (table 3). According to Brown's classification, one case each of I, II C, and III was distributed among the three methods.

Table 2: Patients demographics

Patient	Method	Brown class	Age	Gender	Operation date
A	1	I	55	M	2021-09-14
B	1	IIC	49	F	2020-09-21
C	1	III	46	F	2020-10-19
D	2	I	80	M	2022-01-17
E	2	IIC	37	M	2022-02-08
F	2	III	51	F	2022-02-07
G	3	I	52	M	2022-05-30
H	3	IIC	29	M	2022-07-25
I	3	III	46	M	2022-07-18

Table 3: Patients characteristics & distribution according to methods

Number of patients according to:		Method		
		one	**Two**	**Three**
Timing of reconstruction	Primary	2	3	3
	Secondary	1	0	0
Number of segments	One	1	1	1
	Two	2	0	1
	Three	0	2	1
Type of reconstruction plates	Pre-bent reconstruction	1	3	3
	Mini	2	0	0
Pre radiotherapy	Yes	1	0	0
	No	0	0	0
Diagnosis	Ameloblastoma	1	1	2
	SCC	1	1	1
	Osteosarcoma	0	1	0
	ORN	1	0	0
Two team	Yes	0	2	1
	No	3	1	2
Tracheostomy	Yes	2	2	2
	No	1	1	1

None of the cases had flap fail. Hospital stay (24.3 ± 18.8 days) was least in method 2 which uses the sagittal saw with mandible fixation guide and fibula guide, however, the difference between the methods was statistically not significant ($p>0.05$). Post-operation patients' condition in (table 4) showed that all of the flaps succeeded. The hospital stay was the most for method 1 which uses the reciprocating saw with fibula guide without mandibular fixation guide, however, the difference between the methods was statistically not significant ($p>0.05$).

Table 4: Post-op Patients' Condition

		Method		
		1- Reciprocating saw + fibula guide	2- Sagittal saw + fibula guide + mandible fixation guide	3- Sagittal saw + fibula guide with predrilled holes
Flap fail	Yes	0	0	0
	No	3	3	3
Complication	None	0	3	3
	Doner site infection	0	0	0
	Claw toe	0	0	0
	Gait disturbance	0	0	0
Hospital stays (days)	p-value	*Mean ± SD*		
	.491	38.0 ± 24.9	24.3 ± 18.8	24.5 ± 2.5

The surgical outcomes of patients are shown in figure 7 and table3. The mean ± sd total op time (433.7 ± 79.5 mins), harvesting time (86.3 ± 35.1 mins), ischemic time (77.0 ± 13.5), and reconstruction time (163.3 ± 31.6 mins) were least in the sagittal saw and predrilled holes at the fibula guide. (figure 7) (Table 5)

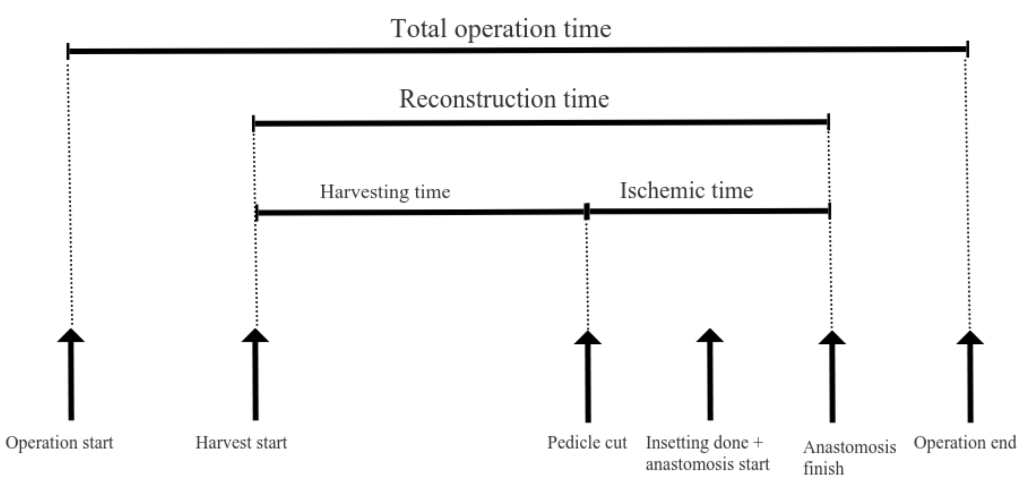
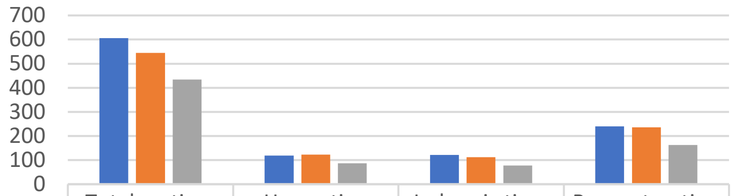


Figure 7 Operation time intervals.

Table 5 Surgical outcomes of the three different methods.



	Total op time (mins)	Harvesting time (mins)	Ischemic time (mins)	Reconstruction time (mins)
Method 1: Reciprocating saw and fibula guide	605.3	119	121.3	240.3
Method 2: Sagittal saw with mandible fixation guide and fibula guide	544	123.3	112.7	236
Method 3: Sagittal saw and predrilled holes at the fibula guide	433.7	86.3	77	163.3

Mandibular width difference (3.8 ± 2.4 mm), angle between segments (3.6 ± 1.0 mm), and cloud distance (max. distance and avg. distance) (6.9 ± 2.3 mm and 1.1 ± 0.5 mm) was least in sagittal saw with mandible fixation guide and fibula guide method. Only the mandibular AP length difference (5.1 ± 2.7 mm) was least in reciprocating saw and fibula guide method. However, the Kruskal-Wallis test showed that none of the differences between the groups were statistically significant (p>0.05). (figure 8)

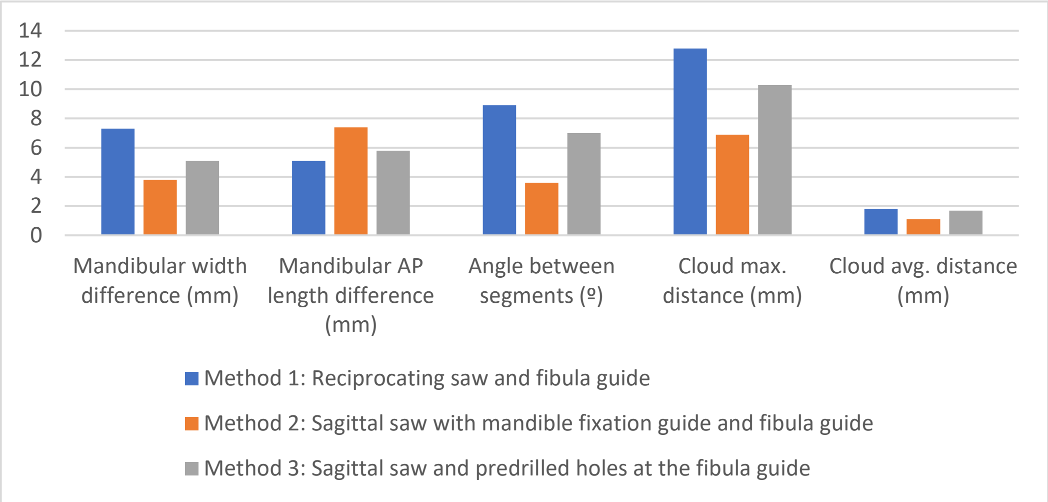


Figure 8 Surgical accuracy of the three different methods.

All the STL models for the patients were superimposed and compared using Cloud Compare software. Since green color indicates that the deviation was less than 1.0 mm, while red color indicates 4 mm difference or more and blue indicate -3 or less, we can notice all patients with method 1 which uses reciprocating saw with fibula guide are the lowest accuracy among other methods. (Figure 9)

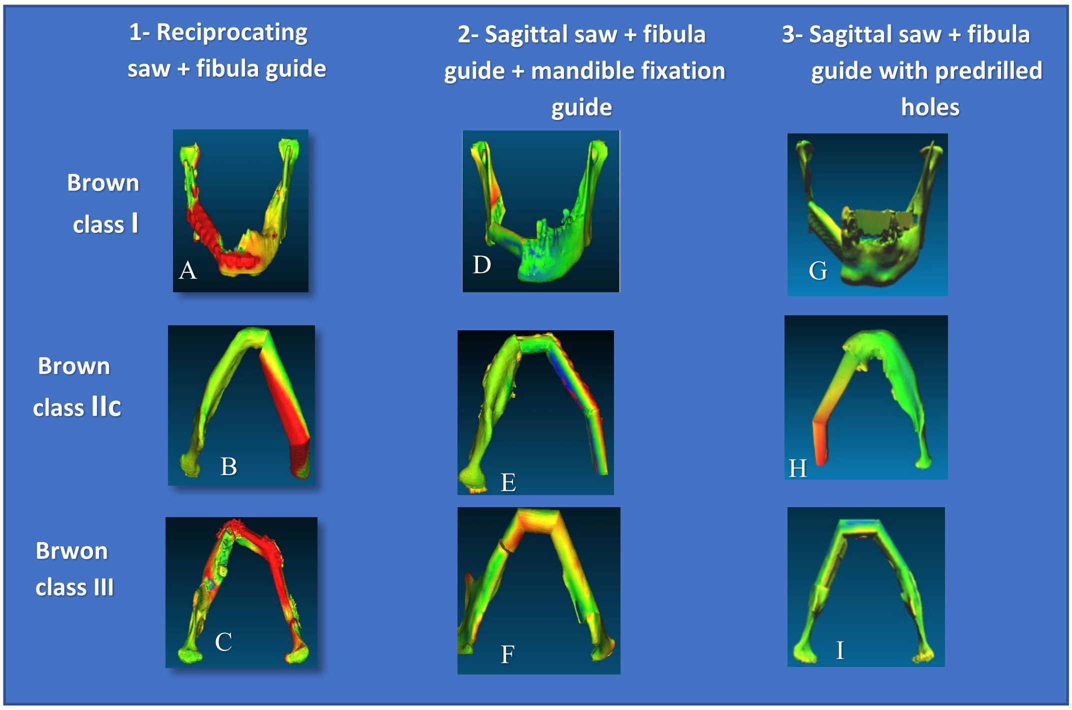


Figure 9: Superimposition of both pre & post-STL models using Cloud Compare software for all the patients. Method 1, which uses a reciprocating saw with a fibula guide, shows the least accuracy among other methods.

DISCUSSION

Surgeons can simulate operations virtually with the use of 3D modeling. There are many advantages of 3D model-based mandibular reconstructions, including enhanced surgical accuracy, shorter operation, and flap ischemic times, and increased result predictability (34-36).

In this study, we presented a detailed description of the fibular reconstruction of a mandibular defect using 3 different methods. We applied different methods in evaluating the accuracy of all methods. Although the overall surgical accuracy was good, a few outliers were noted in our study. These deviations might be because of different reasons such as the use of mini plates vs prebent reconstruction plates and improper trimming of bone edges, which is one of the drawbacks of using the reciprocating saw because the saw length can reach up to 20 mm while the width of the fibula is around 10-20 mm. If the fibula guide is added 5-10 mm extra thickness to the planned cutting is forcing the surgeon to lead by free cutting without the fibula guide which is time-consuming on the contrary, the sagittal saw in method 2 and 3 has a length of up to 25.5 mm which is enough to give stability and support to cut with the fibula guide, and because in the beginning we were using the reciprocating saw and we noticed this drawback we considered changing to another techniques (Figure 10 & 11).

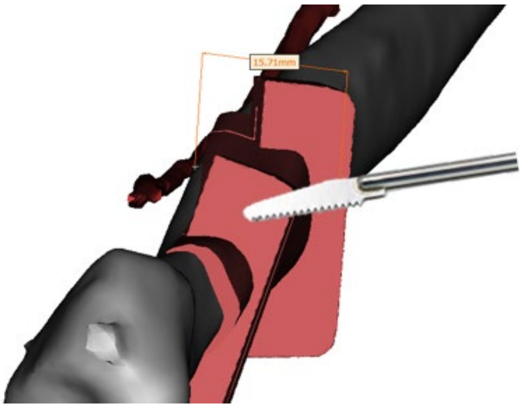


Figure 10: Reciprocating saw at fibula guide cannot reach to the desire length.

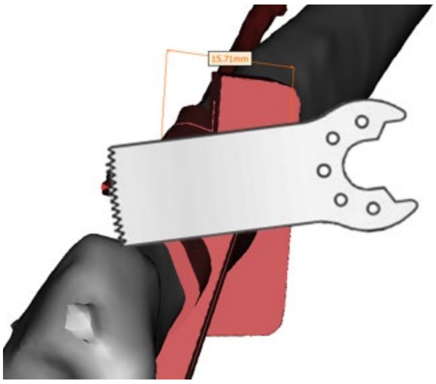


Figure 11: Sagittal saw at fibula guide reaching to the desire length.

Positioning device (mandibular fixation guide) was reported which allows the exact placement of prebent titanium plates with respect to the planned position of the fibula segments. No similar studies compared these three methods. Prebent plates served as the positioning devices, another function of these devices is to guarantee that fibula segments are placed within the correct contours. The drill holes in the cutting guides served as a secondary device to ensure a correct relationship between the plate and bone segments. In our opinion using the predrilled holes at fibula guide provide the surgeon with a more reliable position.

In our study, all of the flaps succeeded, and the plates were fitted perfectly. The occlusion and patient appearance were optimal. In this study we believe that we cannot rely on total operation time alone as a tool to know which method with less time-consuming since there are different circumstances for every procedure, for example, operation with tracheostomy before needs more time on the other hand some operations were done by two team approach which for sure will be a factor for reducing total operation time also patients with previous treatment with radiotherapy will be a time-consuming factor because care must be taken when dealing with fibrous tissue not to injure important structure in the neck [40], on the other hand harvesting time and ischemic time cannot be affected by any of the previous factors for that reason they can be a reliable indicator for the efficacy of time-saving, we reported and compared them in order to know which method is more time-saving and with less ischemic time which is a factor for free flap prognosis

According to Chang et al. [37], an ischemic time of more than 93 min could lead to the failure of breast-free flaps [38]. Mentioning that an ischemic time up to 90 min was safe in a limited number of microvascular muscle-free flaps. Our mean ischemic time was 121.3 ± 25.2 min, 112.7 ± 24.1min, and 77.0 ± 13.5min for methods 1 which uses reciprocating saw, 2 which uses the sagittal saw with mandible fixation guide, and 3 which uses the sagittal saw with predrilled holes at fibula guide respectively. Showing that method 3 which uses the sagittal saw with predrilled holes at fibula guide is the only method with lower than 93min.

CONCLUSION

CAS using method 3 which uses the sagittal saw with predrilled holes at fibula guide is more convenient for the operator and could benefit the patient in terms of less ischemic time. Overall surgical accuracy was good, but a few outliers were noted in our study. Further studies recommended with the implementation of a higher number of patients as in this study the number of patients is limited

REFERENCE

1. Hidalgo PA. Fibula free flap: a new method of mandible reconstruction. Plast Reconstr Surg 1989;84:71–9.
2. Cordeiro PG, Disa JJ, Hidalgo DA, Hu QY. Reconstruction of the mandible with osseous free flaps: a 10-year experience with 150 consecutive patients. Plast Reconstr Surg 1999;104:1314–20.
3. Hidalgo DA, Pusic AL. Free-flap mandibular reconstruction: a 10-year follow-up study. Plast Reconstr Surg 2002;110:438–49.
4. Hölzle F, Kesting MR, Hölzle G, et al. Clinical outcome and patient satisfaction after mandibular reconstruction with free fibula flaps. Int J Oral Maxillofac Surg 2007;36:802–6.
5. López-Arcas JM, Arias J, Del Castillo JL, et al. The fibula osteomyocutaneous flap for mandible reconstruction: a 15-year experience. J Oral Maxillofac Surg 2010;68:2377–84.
6. Wallace CG, Chang YM, Tsai CY, Wei FC. Harnessing the potential of the free fibula osteoseptocutaneous flap in mandible reconstruction. Plast Reconstrue Surg 2010;125:305–14.
7. Thankappan K, Trivedi NP, Subash P, et al. Three-dimensional computed tomography-based contouring of a free fibula bone graft for mandibular reconstruction. J Oral Maxillofac Surg 2008;66:2185–92.

8. Roser SM, Ramachandra S, Blair H, et al. The accuracy of virtual surgical planning in free fibula mandibular reconstruction: comparison of planned and final results. J Oral Maxillofac Surg 2010;68:2824–32.
9. Dong Z, Li B, Xie R, Wu Q, Zhang L, Bai S. Comparative study of three kinds of fibula cutting guides in reshaping fibula for the reconstruction of mandible: an accuracy simulation study in vitro. J Craniomaxillofac Surg 2017;45:1227–35.
10. Toto JM, Chang EI, Agag R, Devarajan K, Patel SA, Topham NS. Improved operative efficiency of free fibula flap mandible reconstruction with patient-specific, computer-guided preoperative planning. Head Neck 2015;37:1660–4.
11. Avraham T, Franco P, Brecht LE, et al. Functional outcomes of virtually planned free fibula flap reconstruction of the mandible. Plast Reconstr Surg 2014;134:628–34.
12. Metzler P, Geiger EJ, Alcon A, Ma X, Steinbacher DM. Three-dimensional virtual surgery accuracy for free fibula mandibular reconstruction: planned versus actual results. J Oral Maxillofac Surg 2014;72:2601–12.
13. Chang EI, Jenkins MP, Patel SA, Topham NS. Long-term operative outcomes of preoperative computed tomography-guided virtual surgical planning for osteocutaneous free flap mandible reconstruction. Plast Reconstr Surg 2016;137:619–23.
14. Weitz J, Bauer FJ, Hapfelmeier A, Rohleder NH, Wolff KD, Kesting MR.

Accuracy of mandibular reconstruction by three-dimensional guided vascularised fibular free flap after segmental mandibulectomy. Br J Oral Maxillofac Surg 2016;54:506–10.

15. Eckardt A, Swennen GR. Virtual planning of composite mandibular reconstruction with free fibula bone graft. J Craniofac Surg 2005;16:1137–40.
16. Hirsch DL, Garfein ES, Christensen AM, Weimer KA, Saddeh PB, Levine JP. Use of computer-aided design and computer-aided manufacturing to produce orthognathically ideal surgical out comes a paradigm shift in head and neck reconstruction. J Oral Maxillofac Surg 2009;67:2115–22.
17. Antony AK, Chen WF, Kolokythas A, Weimer KA, Cohen MN. Use of virtual surgery and stereolithography-guided osteotomy for mandibular reconstruction with the free fibula. Plast Reconstrue Surg 2011;128:1080–4.
18. Valentini V, Agrillo A, Battisti A, Gennaro P, Calabrese L, Iannetti G. Surgical planning in reconstruction of mandibular defect with fibula free flap: 15 patients. J Craniofac Surg 2005;16:601–7.
19. Chopra K, Manson PN, Gastman BR. Stereolithographic modeling in reconstructive surgery of the craniofacial skeleton after tumor resection. Plast Reconstr Surg 2012;129:743–5.
20. Sharaf B, Levine JP, Hirsch DL, Bastidas JA, Schiff BA, Garfein ES. Importance of computer-aided design and manufacturing technology in the multidisciplinary

approach to head and neck reconstruction. J Craniofac Surg 2010;21:1277–80.

21. Stirling Craig E, Yuhasz M, Shah A, et al. Simulated surgery and cutting guides enhance spatial positioning in free fibular mandibular reconstruction. Microsurgery 2015;35:29–33.
22. Lim SH, Kim YH, Kim MK, Nam W, Kang SH. Validation of a fibula graft cutting guide for mandibular reconstruction: experiment with rapid prototyping mandible model. Comput Assist Surg 2016;21:9–17.
23. Liu XJ, Gui L, Mao C, Peng X, Yu GY. Applying computer techniques in maxillofacial reconstruction using a fibula flap: a messenger and an evaluation method. J Craniofac Surg 2009;20:372–7.
24. Haddock NT, Monaco C, Weimer KA, Hirsch DL, Levine JP, Saadeh PB. Increasing bony contact and overlap with computer-designed offset cuts in free fibula mandible reconstruction. J Craniofac Surg 2012;23:1592–5.
25. Rodby KA, Turin S, Jacobs RJ, et al. Advances in oncologic head and neck reconstruction: systematic review and future considerations of virtual surgical planning and cocomputer-aided design/computer aided modeling. J Plast Reconstr Aesthet Surg 2014;67:1171–85.
26. Rohner D, Bucher P, Hammer B. Prefabricated fibular flaps for reconstruction of defects of the maxillofacial skeleton: planning, technique, and long-term experience. Int J Oral Maxillo fac Implant 2013;28:221–9.

27. Brown JS, Barry C, Ho M, Shaw R. A new classification for mandibular defects after oncological resection. Lancet Oncol. 2016 Jan;17(1):e23-30. doi: 10.1016/S1470-2045(15)00310-1. Epub 2015 Dec 23. PMID: 26758757.
28. van Baar GJC, Liberton NPTJ, Winters HAH, Leeuwrik L, Forouzanfar T, Leusink FKJ. A Postoperative Evaluation Guideline for Computer-Assisted Reconstruction of the Mandible. J Vis Exp. 2020 Jan 28;(155). doi: 10.3791/60363. PMID: 32065152.
29. @L@Schepers, R.H.; Kraeima, J.; Vissink, A.; Lahoda, L.U.; Roodenburg, J.L.; Reintsema, H.; Raghoebar, G.M.; Witjes, M.J. Accuracy of secondary maxillofacial reconstruction with prefabricated fibula grafts using 3D planning and guided reconstruction. J. Craniomaxillofac. Surg. 2016, 44, 392–399. [CrossRef]
30. Wilde F, Plail M, Riese C, Schramm A, Winter K. Mandible reconstruction with patient-specific pre-bent reconstruction plates: comparison of a transfer key method to the standard method–results of an in vitro study. Int J Comput Assist Radiol Surg 2012;7:57–63. W.-f. Yang et al. Oral Oncology 78 (2018) 31–36
31. Zheng GS, Su YX, Liao GQ, Jiao PF, Liang LZ, Zhang SE, et al. Mandible reconstruction assisted by preoperative simulation and transferring templates: cadaveric study of accuracy. J Oral Maxillofac Surgery 2012;70:1480–5.
32. Zheng GS, Su YX, Liao GQ, Liu HC, Zhang SE, Liang LZ. Mandibular

reconstruction assisted by preoperative simulation and accurate transferring templates: preliminary report of clinical application. J Oral Maxillofac Surgery 2013;71:1613–

33. van Baar GJC, Liberton NPTJ, Winters HAH, Leeuwrik L, Forouzanfar T, Leusink FKJ. A Postoperative Evaluation Guideline for Computer-Assisted Reconstruction of the Mandible. J Vis Exp. 2020 Jan 28;(155). doi: 10.3791/60363. PMID: 32065152.
34. Seruya M, Fisher M, Rodriguez ED. Computer-assisted versus conventional free fibula flap technique for craniofacial reconstruction: an outcomes comparison. Plast Reconstr Surg 2013;132(5):1219–28.
35. Eckardt A, Swennen GRJ. Virtual planning of composite mandibular reconstruction with free fibula bone graft. J Craniofac Surg 2005;16(6):1137–40.
36. Succo G, Berrone M, Battiston B, et al. Step-by-step surgical technique for T. Bao et al. Oral Oncology 75 (2017) 133–139 138 mandibular reconstruction with fibular free flap: application of digital technology in virtual surgical planning. Eur Arch Otorhinolaryngol 2015;272(6):1491–501
37. Chang EI, Chang EI, Soto-Miranda MA, et al. Comprehensive evaluation of risk factors and management of impending flap loss in 2138 breast free flaps. Ann Plast Surg 2014. PMID: 25003429.
38. Dragu A, Schnürer S, Surmann-Schmitt C, Unglaub F, Kneser U, Horch RE.

Expression of HIF-1α in ischemia and reperfusion in human microsurgical free muscle tissue transfer. Plast Reconstr Surg 2011;127(6):2293–300.

39. Avraham T, Franco P, Brecht LE, et al. Functional outcomes of virtually planned free fibula flap reconstruction of the mandible. Plast Reconstr Surg 2014;134(4):628e–34e.
40. Wei WI, Ho WK, Cheng ACK, et al: Management of extensive cervical nodal metastasis in NPC after radiotherapy—A clinicopathological study. Arch Otolaryngol Head Neck Surg 127:1457-1462, 2001

Abstract in Korean

비골 유리혈관화 피판에서 가상 수술 계획의 효율성 및 정확성 : 3가지 다른 방법에 대한 비교연구

서론

하악골 재건에서 컴퓨터 보조 수술방법은(Computer-assisted surgery, CAS) 이전의 수술방법에 비해 수술 후 결과가 예측 가능하다는 측면에서 그 기술의 가치를 입증했다. 이 연구에서는 세 가지 다른 방법을 사용하여 하악골

재건에서 컴퓨터 보조 수술 가이드의 정확성과 효과를 보고하고 비교하였다. 첫 번째 방법은 모터 구동식 saw를 사용하지만 하악골 고정 가이드를 사용하지 않았으며, 두 번째 방법은 공기압 구동식 sagittal saw를 사용하지만 하악골 고정 가이드와 비골 가이드를 모두 사용했다. 그리고 세번째는 공기압 구동식 sagittal saw를 사용하되 미리 뚫은 비골 구멍 가이드를 사용했다.

방법

2019년부터 2022년까지 본원에서 컴퓨터 보조 수술(CAS)을 이용하여 하악골 재건술을 받은 9명의 환자를 대상으로 하악골 결손에 대한 후향적 연구이다. 환자 정보,진단, 보조 요법의 유무, 사용한 고정 판의 종류, 골절개 수, 총 수술 시간, 허혈 시간, 재건 시간, 총 입원 일수, 합병증, 수술 전후 모델을 사용한 구조 정확도를 평가했다.

결과 및 고찰

방법 3개를 각각 사용하여 연구에 포함된 환자는 9명으로 플랩이 있는 모든 사례에서 하악골 고정 가이드 없이 시상 톱과 비골 가이드의 사전 드릴링 홀을 사용한 방법 3이 가장 낮은 허혈 시간을 보였다. 전체적인 수술 정확도는 좋았지만, 연구를 통해 몇 가지 특이한 수치가 관찰되었다. 결론적으로 컴퓨터 보조 수술(CAS)은 시상 톱과, 비골 가이드에 미리 구멍을 뚫어 놓은 가이드를 사용하는 것이 시술자에게 더 편리하고 허혈 시간이 적다는 측면에서 환자에게 유용하였다. 전체적인 수술 정확도는 모든 방법에서 비슷했지만 모터 구동식 saw와 비골 가이드를 사용하지만 하악골 고정 가이드가 없는 방법1은 가장 정확하지 않다. 이 연구에서는 연구에 포함된 환자 수가 제한되어 있기 때문에 더 많은 수의 환자에 대한 추가적인 연구가 필요할 것이다.