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Research paper

In-house virtual surgical planning for mandibular reconstruction with fibula free flap: Case series and literature review

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ABSTRACT

The fibula free flap (FFF) surgery has long been used for complicated mandibular reconstruction. Virtual surgical planning (VSP) has been incorporated into the reconstruction planning by surgeons and has been found to reduce operating time and surgeon stress intraoperatively. When compared to traditional reconstruction, VSP enhances accuracy, surgical efficiency, and clinical outcomes. However, VSP on the other hand, need advanced technology such as software and 3D printing equipment, which are not always accessible in all centres. We describe our workflow on VSP reconstruction of the mandible with FFF by using open-source software.

Methods: Three patients underwent mandible reconstruction with FFF. VSP was used for all reconstruction planning.

Results: The mean operative time was min 765 minutes (range: 615 – 960 minutes), the mean ischemic time was 260 minutes (range: 120 – 355 minutes) and the mean length of stay was 10.7 days (range: 10 – 12 days). There were no flap failures. There were no major complications.

Conclusion: VSP is a very viable method that saves time and cost, making surgery more efficient.

Introduction

The oral and maxillofacial structures have many important functional and aesthetic components. Resection of these structures may impair these units, reducing patients' quality of life (QoL) significantly. Restoration and reconstruction of the function and aesthetic in the maxillofacial regions now have been considered as important as primary ablative surgery. However, reconstruction surgery has become more complex due to advanced technology and patient demand. Hidalgo was the first to describe FFF for mandibular reconstruction in 1989 [1]. Nowadays, many centres considered mandibular reconstruction with FFF as the 'state of the art' where fibula is the primary choice for reconstruction in the maxillofacial regions [2]. The fibula is a long and straight bone. Once harvested, it can be osteotomised in several segments and shaped to follow the curvature of the jaws[1]. The thick bicortical bone of the fibula can be used for dental implantation and rehabilitation [3].

Reconstruction of the mandible with fibula is a complex procedure, considering facial contour, angles and location of osteotomies and position of future dental implants. Various methods have been used to minimise errors pre-operative and intra-operatively [4,5]. This includes prebending of reconstruction plates and trial cutting of printed 3D fibula models. However, even with experience surgeons, executing the 'free hand' mandibular reconstruction is considered very challenging. VSP includes 3D planning with the generation of 3D models and customised cutting guides. Patient-specific implants/plates (PSI/ PSP) also can be incorporated into the planning. When it is planned correctly, PSP can solve the problem of 'guesswork' intraoperatively, thus reducing operation time and surgeon's stress [6].

Department of Oral and Maxillofacial Surgery, Queen Elizabeth I Hospital has been using VSP since 2012. This includes 3D image segmentation, mirroring, and printing of 3D models for trauma, craniofacial deformity, secondary defect, and tumour cases. However, for complex reconstruction requiring fibula, more advanced software and equipment are required. VSP has proved extremely useful during the preoperative phase and 3D Slicer software is used for all patients involved in this study. The newly developed functionality (Bone Reconstruction Planner, BRP) in 3D Slicer is designed exclusively for mandibular reconstruction using fibula make planning faster and more accurate. Thus, our main objectives in this study are:

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Table 1
comparative studies between VSP and non-VSP for mandible reconstruction with fibula.

Author	Software	Study type	Accuracy	Efficiency (operation time, ischemic time, length of hospital stays, LOS)	Complications/ long-term outcome	Cost*
Avraham et.al 2014 [13]	Not mentioned	Retrospective	Not assessed	Favours VSP	No difference in terms of overall complications. Favours VSP on dental rehabilitation and QoL	Less cost in VSP group
Zweifel et al. 2015 [7]	Proplan CMF	Retrospective	Not assessed	Favour VSP on total operation time	Not assessed	VSP have extra expense
Wang et al. 2016 [8]	Proplan CMF	Retrospective	Favours VSP	Favours VSP	Favours VSP	Not assessed
Yu et al. 2016 [14]	Surgicase CMF	Retrospective	Favours VSP	Favours VSP	Not assessed	Not assessed
Zhang et al. 2016 [15]	Surgicase CMF and Geomagic	Retrospective	Favours VSP	Not assessed	Not assessed	Not assessed
Tarsitano et al. 2016 [16]	Rhino 4.0	Prospective	Not assessed	Favours VSP	Fewer complications in VSP	Less cost in VSP
Bao et al. 2017 [17]	Geomagic	Retrospective	Favours VSP	Favours VSP	Not assessed	Not assessed
Rommel et.al 2017 [11]	ProPlan CMF	Retrospective	Not assessed	Favours VSP	Not assessed	Less cost in non-VSP
Ren et al. 2018 [18]	Mimics	Retrospective	Favours VSP	Reduced operation time and reconstruction time	Fewer complications in VSP	Not assessed
Mahendru et al. 2020 [9]	ProPlan CMF	Prospective	Favours VSP	Favours VSP	Favours VSP on aesthetic score and occlusion	Less cost in non-VSP
Wang et al. 2020 [19]	3D Slicer	Prospective	Favours VSP	Favours VSP	Not assessed	Not assessed
May et al. 2021 [10]	Proplan CMF	Retrospective	Favours VSP	Favours VSP	Favours VSP – reduces the rate of non-union	Not assessed

*Cost: VSP group including VSP services, 3D printing of customised cutting guide, titanium plates and hospital costs (operation theatre and hospital stays). Non-VSP group only titanium plates and hospital costs.

1 To demonstrate the use of 3D Slicer software and BRP for mandibular reconstruction with FFF.
2 To describe VSP-based surgery and its clinical outcomes.

Literature review

There have been several comparative studies done on VSP versus traditional mandibular reconstruction with FFF as shown in Table 1. Accuracy, efficiency (operation time and length of stay, LOS), complications, outcomes, and cost are all measured. Majority of the studies in favour of VSP-based surgery on accuracy, efficiency, and less complications [7–11]. For cost-benefit of VSP-based surgery, systematic reviews and meta-analysis studies have demonstrated that VSP have lesser overall cost than the traditional approach associated with reduced operation time and hospitalization [4,12].

No comparative investigation can be conducted in this study since no conventional mandibular reconstruction with FFF has ever been performed at this centre. Most reconstructions are done using an iliac free block bone graft and a reconstruction plate alone. Even though no free-hand reconstruction has ever been tried owing to its technically challenging procedure, we are confident in carrying it out because of the availability of VSP software in-house.

Methods

From November 2021 until April 2022, 3 patients underwent mandibular reconstruction with FFF. Each case is presented and discussed among surgeons to determine the approach, osteotomy cuts, number of bony segments required, the recipient vessels, donor legs sides and position of pedicles. All cases are planned virtually using free open-source software (3D Slicer) for the generation of 3D reconstructed mandible models, and mandible and fibula cutting guides. The BoneReconstructionPlanner (BRP) module was installed as a 3D Slicer's extension. Step-by-step YouTube tutorial is viewed and attentively followed [20]. A written instruction was carefully analysed to have a better understanding of the BRP functionality [21]. Patients' details are shown in Table 2. The reconstruction planning was divided into 3 phases: acquisition phase (pre-operative), planning phase (pre-operative) and reconstruction phase (intra-operative).

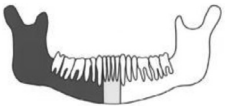
Acquisition Phase (Pre-Operative)

1) Computed tomography (CT) scan of the craniofacial skeleton and CT angiography of lower limbs are taken. It is advised to take scans with slice thicknesses at least 1mm and below for any image-guided surgery. Arterial branches from the lower leg are assessed for a potential donor. The selection of the donor's leg depends on the location of pedicle bases (anterior or posterior base) and recipient vessels (ipsilateral or contralateral).
2) Digital Imaging and Communications in Medicine (DICOM) data was uploaded in 3D Slicer software and segmentation is done.

Planning Phase (Pre-Operative)

1) 3D reconstructed images are reviewed (Fig. 1a). Resection is planned on the virtual model. Surgical margins are set about 1.5cm away from the radiological margin of the lesion (Fig. 1b).
2) Cutting planes are positioned carefully on the mandible to form the desired curvature of the mandible. The more severe the defect the greater number of osteotomies are required (Fig. 1c).
3) Condyle and angle of mandible positions are very important for final functional and aesthetic reconstruction. Fibula positions and symmetry are reviewed and assessed both from lateral and bottom views (Fig. 1d – 1h)
4) Cutting planes on the mandible are transferred to the fibula automatically by BRP (Fig. 2a).
5) After cutting planes are determined, fibula segments are placed to form the 'neo-mandible' virtually. The position of the fibula segments can be adjusted until a satisfactory symmetrical appearance is achieved (Fig. 1c, 1f, 1h). In situations with deformed anatomy of the mandible caused by tumours, a mirror image of the contralateral side was employed to aid in reconstruction. The normal mandible is used as a guide for determining the angle of the jaw.
6) Virtual cutting guides for both the mandible and fibula are designed (Fig. 2b).
7) Data files were converted to STL before can be 3D printed (Fig. 2c).

Table 2
patient details

Case	1	2	3
Patient age	22	28	20
Gender	Female	Male	Male
Diagnosis	Ameloblastic fibroma of right mandible	Ameloblastoma of the right angle of the mandible	Ameloblastoma of the left angle of the mandible
Brown mandibular defect classification*	Class IVc 	Class IIc 	Class IIc 
Donor Fibula	Left fibula	Left fibula	Right fibula
Number of fibula segments	3	2	2
Fibula length used for reconstruction	170 mm	130 mm	134mm
Printing hours 3D models	19 hours	14 hours	14 hours

* According to mandibular defect classification by Brown et al. [22]

8) The native mandible with a fibula (neo-mandible) in position (Fig. 2e), mandibular cutting guides, and fibula cutting guides (Fig. 2d) were 3D printed with polylactic acid material (PLA) using Flashforge Guider IIS / 2S printer (Fig. 2f).
9) Miniplates were bent and adapted to the printed mandibular reconstruction 3D model, tagged, and then sterilized.

Reconstruction Phase (Intra-Operative)

1) The cutting guides and models were chemically disinfected with Anioxyde 1000 for 15 minutes.
2) A two-team approach was performed in the surgery, with simultaneous resection of the tumour and harvesting of the FFF.
3) Osteotomies of the fibula were done using cutting guides once the flap had been raised. Fibula cutting guides were placed and fitted onto the fibula. Then, fixed with a 20mm stainless steel tapping screw (Fig. 3a, 3b).
4) Miniplates fixed to the fibula segments to maintain the contour and osteotomy angle (Fig. 3d). Plates fixation is made whilst the fibula is still attached to its pedicle.
5) Pedicles are then cut, and the fibula flap is transferred to recipient sites. Prebend plates and screws were fixed to connect the fibula to the native mandible (Fig. 3f).

Results

Collected surgical variables are shown in Table 3. The mean operative time was min 765 minutes (range: 615 – 960 minutes), the mean ischemic time was 260 minutes (range: 120 – 355 minutes) and the mean length of stay was 10.7 days (range: 10 – 12 days). There were no flap failures. There were no major complications (Fig. 4).

Discussions

A total of 3 cases of mandibular ameloblastoma using VSP for reconstruction. In all cases, FFF was used as the donor site. However, the planning also can be applied to other osseous flaps such as deep circumflex iliac artery (DCIA). Reconstructive surgeons have refined the FFF approach many times since its first introduced. Initially, the fibula flap was shaped freehand, with the patient's contralateral anatomy guiding the position of osteotomies and plate placement. The generation and printing of 3D mandibular models have improved operational planning and efficiency. More recently, technological advancements have resulted in the concepts of virtual surgical planning (VSP) [23]. For mandible reconstruction utilising fibula, several methods [24,25,26,27] have been used in VSP, including:

1 VSP with the generation of:
- 3D model of the reconstructed mandible
- Mandible cutting guide with or without positioning screw holes
- Fibula cutting guide with or without positioning screw holes and positioning implant slots.
- Positioning templates or guide
- Patient-specific plates or implants (PSP/ PSI)

2 Adjunct tools to improve intraoperative feedback and accuracy [28,29,14]:
- navigation with image-guided surgery (IGS)

The bigger the tumour the more complex reconstruction requiring the printing of more 3D models and adjunct tools. Reconstructive surgery is nowadays considered as important as ablative surgery. Some centres with more experience may do a 'jaw in a day' surgery where implant-supported prosthesis can be placed immediately intraoperatively [30]. The reconstructive works make sure the patient can back to function as soon as possible and improve the overall QoL in the future [12].

In this study, 3 models were printed for each patient. 3D models of the reconstructed mandible, customised mandibular cutting guide and fibula cutting guides were used intraoperatively to facilitate surgery. Navigation surgery may improve further on the accuracy, but the service is not available as in-house. The aim is to minimise cost and at the same time maximise outcome. VSP was created with free open-source software (3D Slicer) and 3D models were manufactured from an in-house 3D printer utilising polylactic acid (PLA) material for all cases. No positioning guide or templates were used to position the neo-mandible to the native mandible. However, the placement and fixation of fibula segment (neomandible) to the native mandible can be achieved as it relies on reliable bone landmarks. Miniplates were prebend to make sure the plate positioning on the model is replicated intraoperatively. PSP is particularly useful since it prevents the rotation of fibula segments in three planes (yaw, roll, and pitch) mainly during positioning and fixation of fibula segments. BRP cannot generate PSP as it is still on development for functionality. However, the cost involving manufacturing a PSP should be considered.

As with any new method, there was a steep learning curve. The 3D Slicer software, which was recently extended for mandibular reconstruction using fibula (BRP), has its own set of challenges, requiring multiple steps of data segmentation and modification before the development of final products. In author's opinion, difficulties arise

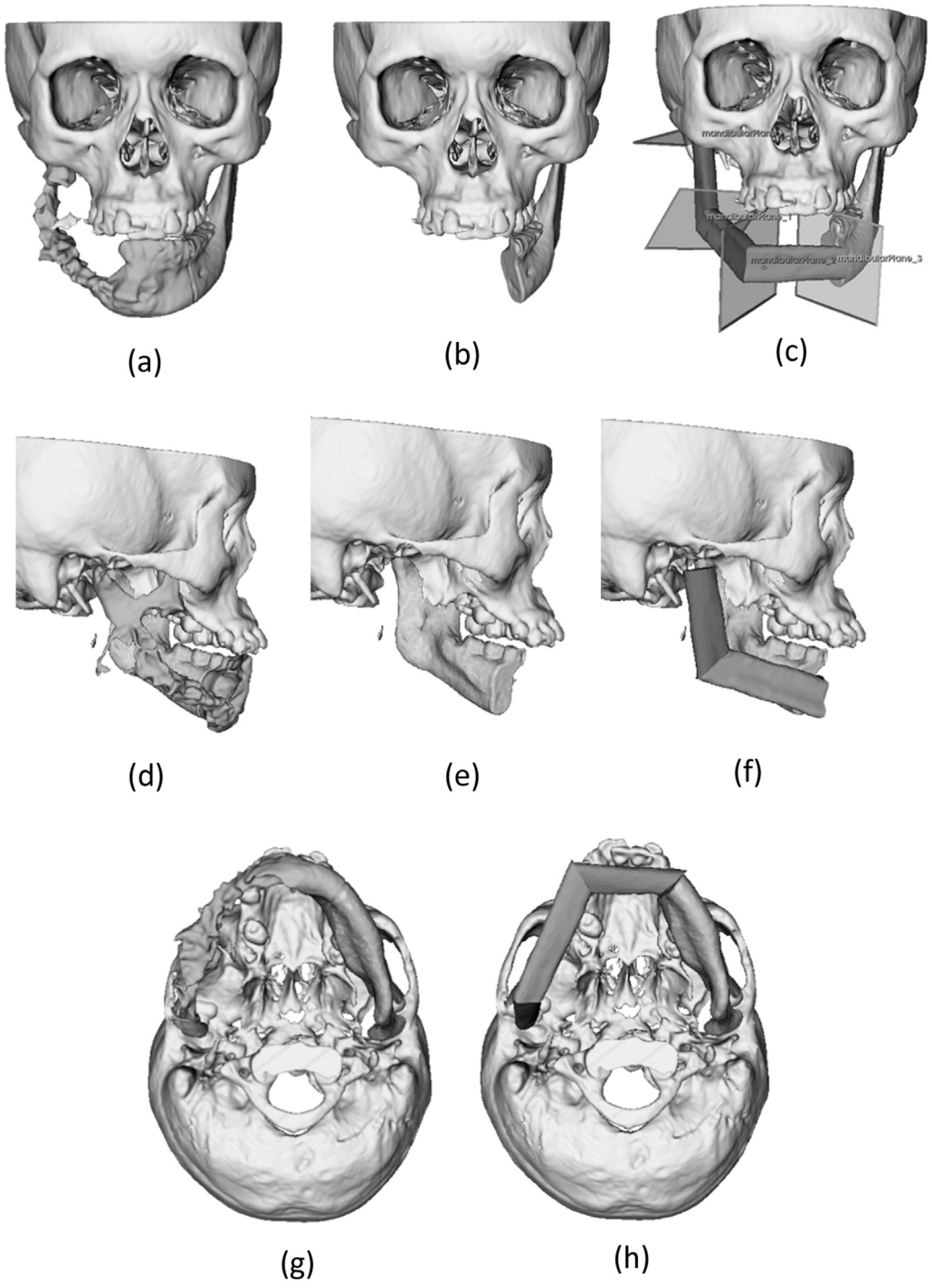


Fig. 1. Virtual surgical planning (VSP) – segmentation and mandible reconstruction. (a)Segmentation of mandible. Noted mandible is separated from the midface and appear in a different colour. (b)Tumour resection is done virtually. (c)Placement of mandibular cutting planes and reconstruction (d)Lateral view of mandible segmentation. (e)Lateral view post-resection. (f) Lateral view post-reconstruction. (g)Bottom view of mandible segmentation (h)Bottom view post-reconstruction.

because not all software are user friendly. However, with consistent practice, the planning can be done quickly. The 3D Slicer software has been used by many for clinical and research purposes including neurosurgery, orthopaedics and cardiothoracic surgery[31]. Although the use of 3D Slicer software is not restricted to research purposes, the FDA still has not approved it for clinical use [32]. Many studies [8,10,13,17] made use of Proplan CMF to aid in VSP. The programme is not open-source, and a licence must be purchased. The VSP also is performed by a qualified technician or biomedical engineer. Despite the versatility of the software, all these factors must be considered when it comes to cost.

In this study, each case is presented and discussed among surgeons (ablative, harvesting and reconstruction team) to determine the approach, osteotomy cuts, number of bony segments required, recipient vessels, donor legs sides and position of pedicles. Most of the time, VSP just involves bones. Soft tissues, such as the amount of muscle left on the fibula and how this affects the fit of cutting guides, should be considered. The fibula cutting guide can be positioned wrongly intraoperatively as it may rotate or slide up and down during fitting [33]. This can be overcome by predetermining the position of the guide virtually, positioning the guide or placing the cutting slots more anterolaterally [33].

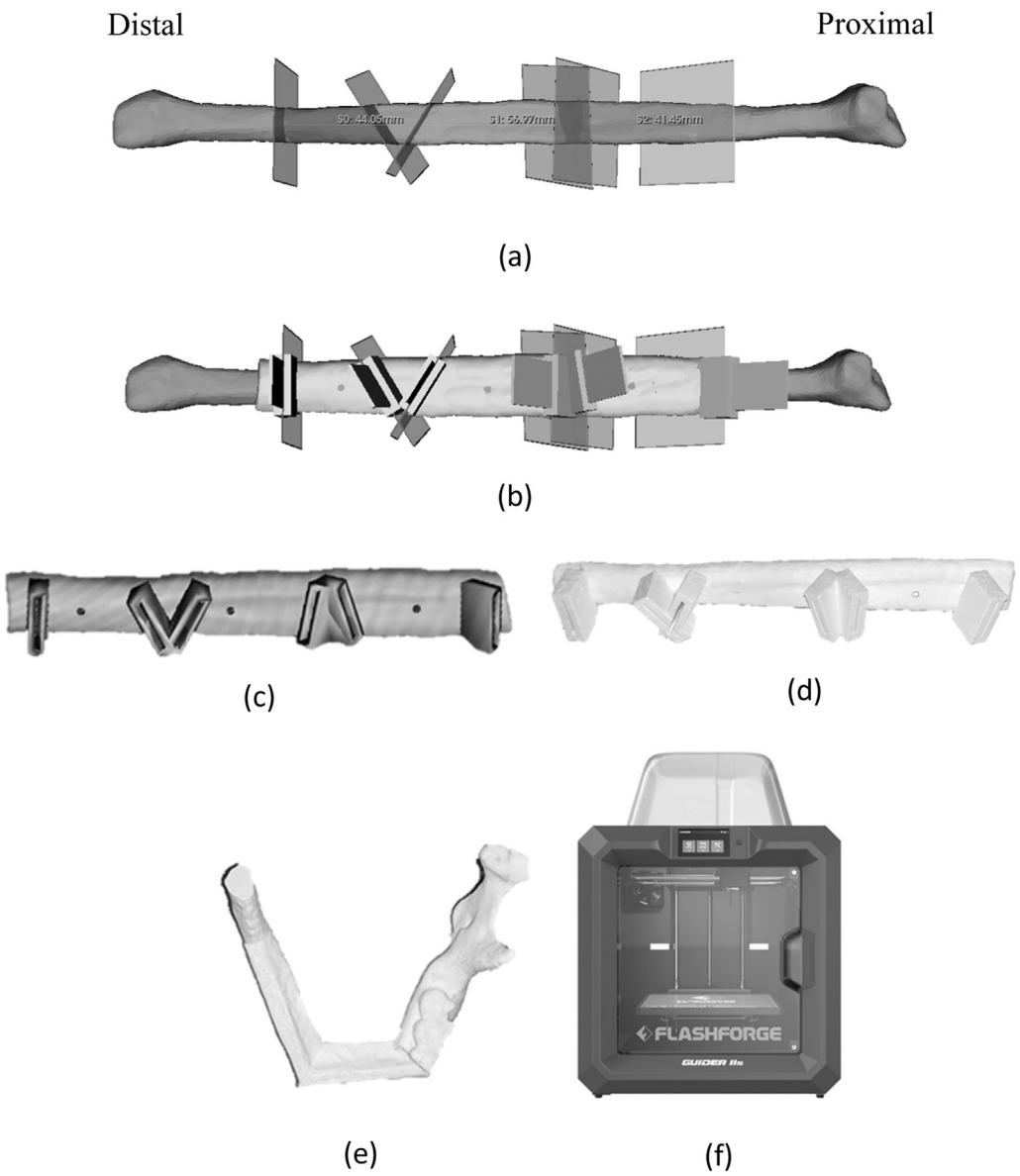


Fig. 2. VSP – fibula cutting guide generation. (a)Fibula bone segmentation with the placement of fibula planes. (b)Generation of fibula cutting guide. (c)Fibula cutting guide in STL format (d)3D printed fibula cutting guide using PLA materials. (e)3D printed reconstructed mandible. (f)3D printer.

Advantages and disadvantages

Accuracy

Accurate and precise reconstruction is vital to ensure optimal aesthetic and functional outcomes. The introduction of VSP has proven to improve surgical outcomes intraoperative and post-operatively [12]. The reconstruction is regarded as accurate if the deviation is within 2 mm [34]. When comparing virtual and actual osteotomy placements, contour, and neomandible form, VSP improved reconstruction accuracy in 93 percent of cases [35]. VSP enhances accuracy in complicated reconstructions that need at least two or more osteotomy segments [12]. Importantly, the use of VSP did not result in a statistically significant increase in complication rates, making it equivalent to standard reconstruction [12]. Many studies assessed the accuracy by comparing pre-operative planning with post-operative CT scans [14,33]. However, no accuracy evaluation was performed in this study because there were no post-operative CT scans done, and it is also not clinically indicated. The satisfactory clinical appearance post-operatively, on the other hand, suggests that the placement and reconstruction were correct. A post-operative CT scan should only be performed if dental rehabilitation and dental implantation are planned.

Cost

When evaluating the cost-benefit of VSP, the rate of complications and the necessary expenditures for longer operations and hospitalizations must be considered. According to reviews and meta-analyses, the cost of VSP services including custom-made cutting guides and PSP ranges from USD3,000 to USD8,200 [4]. Zweifel et al. compared the expenses of 10 VSP reconstructions to 11 freehand reconstructions based only on operating time gain. Despite a mean time gain of 67.4 minutes and a cost savings of USD3201.50, employing VSP had an extra expense [7]. According to Lignon et al [36], the higher expense of virtual surgical planning does not appear to be offset by savings from a shorter operating time, a shorter hospital stay, or a reduction in post-operative complications. However, Tarsitano et al. on the other hand reported a cost savings of USD3467 based only on operative time gains, which was sufficient to counterbalance the higher expenses associated with VSP [16]. The planning, model, and

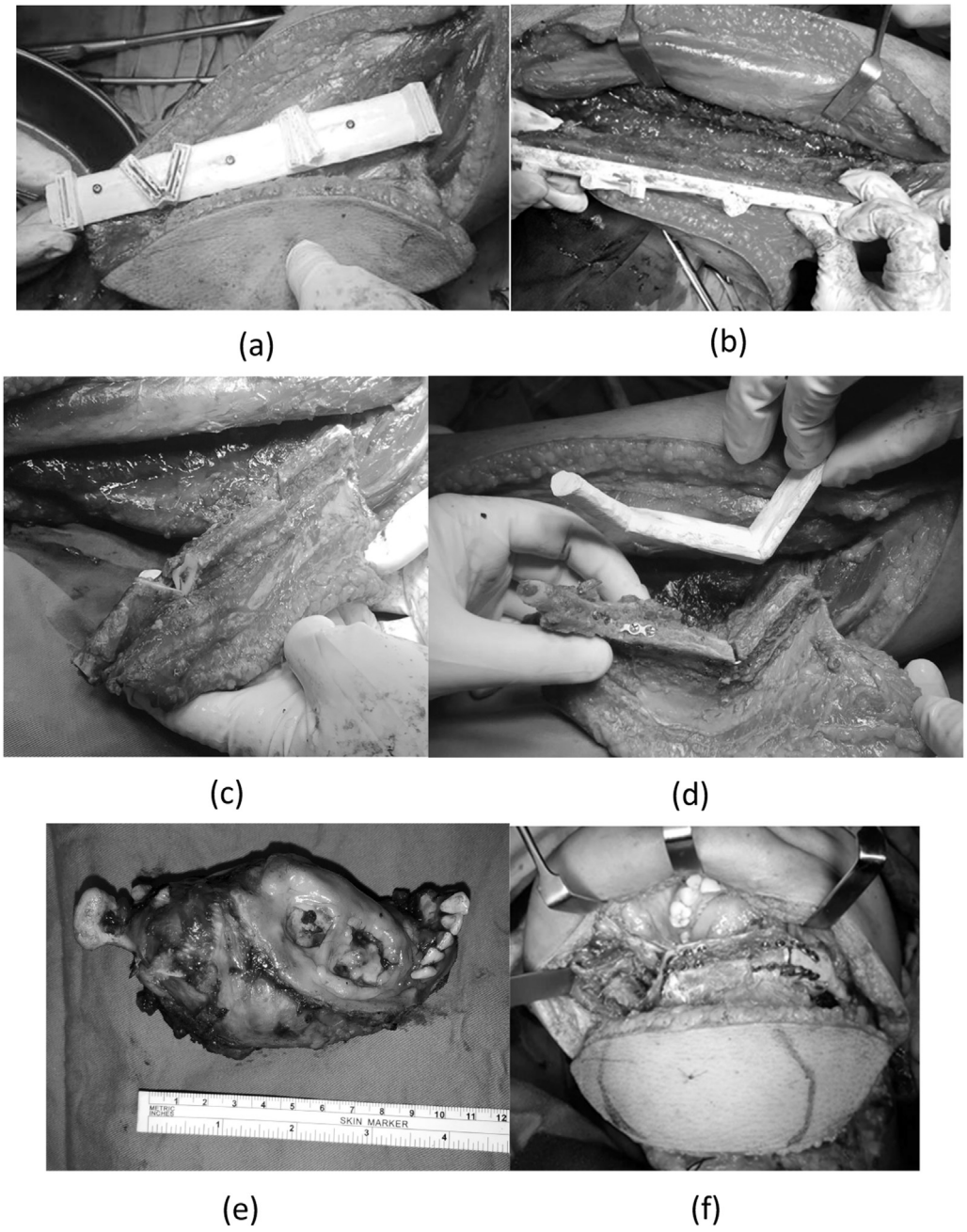


Fig. 3. Intra-operative photos (Case 1). (a)Fibula cutting guide fixed on to the fibula (b)Fitting of fibula cutting guide at the anterior and lateral aspect of the fibula. (c)Osteotomy cuts made. The fibula bone is cut into 3 segments. (d)Miniplates were fixed onto the fibula segments. Pedicles are still attached at this moment. (e)The main tumour was resected. (f)Fibula segments were fixed onto the native mandible to form neomandible.

cutting guides increased the cost of the surgical process; nevertheless, less time may result in lower operating room use expenses [25].

In this study, the overall cost for 1 patient is between USD420 to USD550, which includes model printing and plating systems. The usage of free open-source software and an in-house 3D printer contributed to the cheap cost in all cases. The printing of PSP/PSI may contribute to the increased cost. As a result, only miniplates were used. Bosc et al. estimated their cost per case for in-house design and printing only to be around USD993 [37]. Depending on the complexity of cases and the materials used, a case allocated to a private company in Malaysia for VSP service (including printing of 3D models, cutting guides and PSP) may cost between USD2500 and USD3500. All patients in this study were operated in a government hospital, where the cost of the procedure and ward admission is subsidised. For example, between case 1 and case 2 (Table.2), there is 345 minutes difference in total operation time, but the operation theatre cost is the same. So, we can expect that despite longer operation time for conventional mandibular reconstruction, the cost of operation theatre will be the same. The incorporation of VSP for all patients in this study makes the cost higher but still very cheap as it is done and manufactured in-house. However, VSP makes operation easier, accurate and less complications.

As overall, VSP technology is a useful tool for reducing operating time and LOS without significantly increasing the total expense of the treatment.

Efficiency

When compared to conventional approaches, mandibular reconstruction employing 3D models and preoperatively generated cutting

Table 3
Results. Data obtained from post-operative and discharge notes of each patient

Case	1	2	3	Mean
Total operation time (minutes)	960	615	720	765
Ischemic time (minutes)	355	120	305	260
Length of stay (days)	12	10	10	10.7

guides help to shorten operation time while also increasing the efficacy and precision of the surgical outcome [4,27]. A study by Xiao et al., who explored the feasibility of 3D printing in craniofacial deformity, found improved results with greater predictability of the post-operative result [38]. A study by Chang et al. compared 92 patients who had free flap mandible reconstruction with VSP (n = 43) to those who did not (n = 49), and found a significant reduction in operating time (545 versus 666 minutes; P<0.005) [39]. The longer the operation time the greater the risks of flap failure, general medical problems, and overall patient morbidity [40]. Barr et al. found that utilising VSP as an adjuvant decreased ischemia time by 44.64 minutes [4]. When the ischemic time surpasses 5 hours, it has a deleterious influence on flap outcomes, including greater rates of partial flap loss and overall complications [39]. According to the same author, the great reduction in operation and ischemic time is associated with reduced time of burring, shaping and contouring of bones [39]. In the traditional method, the 'free hand' and guesswork of mandibular reconstruction may lengthen the operation and ischemic time.

In this study, mandibular cutting guide was placed in the planned area of the mandible, allowing for accurate osteotomy cuts to be made. This is to ensure a perfect fitting with a passive placement of fibula segments as the neomandible. Meanwhile, the fibula cutting guides aided in the shaping and contouring of the fibula segments. All rotation of fibula segments in three dimensions is predetermined preoperatively, reducing intraoperative flap manipulation. The fibula segments are still connected to the pedicle at this point (Fig. 3d). Many surgeons will attempt to reshape and contour the fibula segments after the pedicles have been cut. However, this may lengthen the ischemic time and increase the likelihood of flap failure. After plating the fibula segments to the original mandible, anastomosis with the recipient's vessels can be performed.

Long-term outcome and QoL

The time between imaging acquisition and operation date for all patients are ranging from 1 to 2 months. Data images obtained are used for VSP and to determine the surgical margins. However, the actual tumour margin on the day of surgery may differ from what was shown on the CT scan. Delays in treatment can result in undesirable outcomes such as positive margins and the likelihood of recurrence. Many studies [41,42] have recommended that operation should be done at least 2 weeks after the CT scan to prevent problem with surgical margin. However, Insurance approval, surgeon and operating room availability, and anaesthetic clearance are all factors that may influence the operation schedule [41]. In this study, Cone-beam computed tomography (CBCT) is taken 2 weeks before the operation date for the final determination of surgical margins. This is to make sure surgical margins are maintained 1cm from radiographic tumour margins. The histopathological report has shown clear margins (>5mm) in all patients. A study by Palla et al. [41]found that using VSP and cutting guides based on predetermined surgical margins did not compromise margin status in ameloblastoma surgical resections and may also reduce the prevalence of close or positive margins. Even in malignant oral cavity cases, Pu et al [42] found there is no difference between VSP and non-VSP groups on surgical

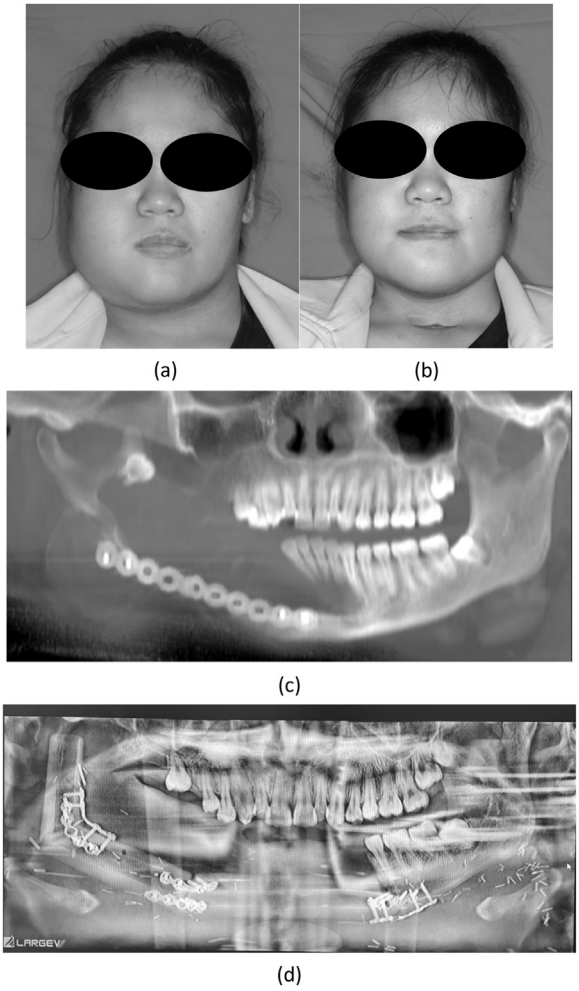


Fig. 4. Clinical photos (case 1). (a)Pre-operative facial appearance. (b)1-month post-operative facial appearance. (c)Pre-operative orthopantomogram. (d)1-month post-operative orthopantomogram.

margins (positive vs negative margins, P = 0.387) and recurrence rate (P= 0.385).

When compared to free-hand reconstruction, VSP minimises the risk of radiographic non-union and flap-related problems in patients having FFF repair for mandibular defects [10]. Non-union is defined as a fracture that is at least 9 months old and has not healed for three months [43]. Chang et al. found 18.6% non-union in conventional surgery compared to VSP which is only 4.1% [39]. During the planning phase (pre-operative), a lot of virtual manipulation is done to get the best reconstruction possible. At the same time, BRP automatically position and rotate all mandibular planes to get a maximum bone-to-bone contact area. By improving bone-to-bone contact between fibular bone segments and the mandible, precision osteotomies with cutting guides promote primary bone repair. Non-union can reduce a patient's QoL by causing pain, discomfort, unsatisfactory physical appearance, mental health issues, physical function degradation, malocclusion, bone atrophy, and weakness [10]. Chewing ability cannot be restored as soon as possible, hence dental rehabilitation is delayed [10].

Although long-term evaluation confirms the accuracy of VSP, there is no clear clinical benefit in terms of patient function [39]. Currently, reconstructive surgery is seen as significant in terms of its benefits on QoL. Many studies have found that chewing ability, followed by speech and appearance, are the most dissatisfied among patients who have had ablative and reconstructive surgery[45,46]. Incorporating immediate dental implantation or prosthesis may help

a patient restore function and improves overall QoL, particularly in benign tumours. Dental rehabilitation after mandibular reconstruction has significant effects on patient QoL and should be carefully considered by the multidisciplinary team caring for patients with mandibular defects [4].

Primary dental implantation allowed a faster return to oral nutrition and prosthesis use than secondary implantation and avoids an additional surgical procedure [3]. VSP opens up new opportunities for anatomically accurate mandibular condyle location and preoperative, prosthetically backward planning for dental rehabilitation [27]. Avraham et.al found that only 22% of patients with non-VSP get immediate dental implants, compared to 30% of individuals with VSP. 5 of their patients with VSP received a "jaw in a day treatment," in which both implants and dental prostheses were put intraoperatively [13]. While Monaco et al. found that 75% of patients with VSP had immediate implant placement achieved full dental rehabilitation and 96% of them tolerated a solid diet [44]. Despite the ability of BRP to do virtual dental implantation, no immediate dental implantation was done in all patients in this study due to financial problems.

This case series have demonstrated that the short-term outcomes are satisfactory and encouraging despite a small number of cases. In addition to possible cost savings and better accuracy, we feel that in-house planning has a significant benefit, particularly in the training of junior surgeons, who face a steep learning curve. The junior surgeons were in charge of all planning, with assistance and discussion from senior surgeons. VSP might be a powerful tool for surgeons who are prepared to make the first commitment on time, training, and costs particularly in head and neck reconstruction surgery. More cases are on the way, all of which will be handled in the same manner**.** There are limited studies on the long-term outcomes of VSP, particularly on functional parameters such as speech, mastication and return to a normal diet, as well as bony union and dental rehabilitation. More research into these concerns is advised.

Conclusion

This case series demonstrates how VSP concepts may be used to enable institutions to design, create, and conduct their operative plans. Preoperative VSP using osteotomy guides greatly enhances communication, improves reconstruction accuracy, and increases predictability and repeatability of surgery, improving the efficiency of mandibular reconstruction using FFF. We recommend starting with easy cases and working the way up to more complex defects.

Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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