ECRONICON OPEN ACCESS

EC DENTAL SCIENCE
Research Article

Three Dimensional Printing of 'Vanperio' Model, a Novel Approach in Periodontics

Liya Anil[1] and K L Vandana[2]*

[1]*Post Graduate Student, Department of Periodontics, College of Dental Sciences, Davangere, Karnataka, India*

[2]*Senior Professor, Department of Periodontics, College of Dental Sciences, Davangere, Karnataka, India*

***Corresponding Author:** K L Vandana, Senior Professor, Department of Periodontics, College of Dental Sciences, Davangere, Karnataka, India.

Received: October 10, 2019; **Published:** November 06, 2019

Abstract

Background and Objectives: The novel idea of 3D printing in the field of periodontics has been implemented to create a model of lower jaw. This model is designed for three important purposes such as patient education and motivation, student activities and demonstration of basic clinical aspects along with periodontal osseous defects. Many of the complex issues in patient education, student learning and demonstration are made simple to the teachers and clinicians. The aim of this paper was to provide information on construction of 3D VANPERIO model and evaluate the feedback from its users for all the purposes.

Methods: Vanperio model was 3D printed using Autodesk Meshmixer software, fused deposition modelling technique and with the help of desired material, Polylactic Acid (PLA). An online survey forms was given to the recipients of vanperio model in and around India which was responded through reply mail.

Results: The maximum response of 53.3% was marked for osseous defects demonstration, followed by demonstration of flossing and interdental brushing (47.8%) and brushing technique (30.4%). Further, the student activity and esthetic presentation received assessment as excellent in 56.5% and 39.1% of feedback.

Interpretation and Conclusion: The vanperio model, a combination of traditional and modern approach, proves to be useful in academic and clinical field to create awareness among patients and comprehensive understanding for the students better than the traditional methods available.

Keywords: *Computer Aided; Rapid Protyping Model; Periodontics; Three Dimensional; Osseous Defects*

Introduction

The process of Three Dimensional Printing (3DP) involves production of 3D solid objects from a STL format (Surface Tessellation Language file or Standard Triangulation Language file) digital file using a 3D Printer by various steps like joining, bonding, polymerization or sintering small volume elements [1]. 3D Printing is also referred as Rapid Protyping (RP).

The manufacturing approach in 3D Printing usually refers to the building of objects layer by layer at a time so that form of object is obtained by adding in multiple layers. The various materials used for depositing or fusing are plastic, metal, ceramic, powders, liquids or the living cells. These RP model system are fully automated and produce 150 units/hour.

In the past decades, cadavers and skeletons were used as study models in field of medicine and dentistry. These are almost replaced by synthetic mannequins and 3D models. The role of 3D printing is rapidly expanding in medical fields and expected to bring about revolutionized health care.[1] The potential and actual medical uses of 3D printing can be categorized broadly as: fabrication of tissue and organ, preparation of customized prosthesis, implants and anatomical models and in research pertinent to pharmacy, discovery, delivery and different drug dosage forms are on way [2].

On the 3D biomodels, different mode surgical procedures can be demonstrated and practiced so as to manage the decision, pre surgical planning and selection of surgical technique [3-5]. In maxillofacial surgeries, 3D printed wafers can be used [5] for mandibular reconstruction [4] and orthognathic surgery [5]. The RP model methods have been become office friendly specially for use in dentistry.

3D printing has wide range of application in different fields of dentistry. In periodontics, fabrication of scaffold for periodontal regeneration have been in process of *in vitro* and *in vivo* trials [5,6].

For two decades, as early as 1995, the natural mandible (lower jaw) was utilized for demonstration of artificially created periodontal osseous defects by the author, a senior clinician and academician in the field of periodontics. This natural bone model served as an inspiration and basis for creation of 3D printed vanperio model @ Vatsalya inventures (www.vinvent.in) who bring importance to those simple inventions occurring in Indian scene to the global front.

Medline search using key words such as rapid prototyping, osseous defects, periodontics didn't reveal any studies. Hence, the current paper has been designed to introduce the construction to vanperio model and its implications for the first time in literature.

Objective of the Study

The objective of the paper was to introduce the educative model, vanperio for educational purposes in the field of periodontics and to evaluate the feedback on its different purposes by the academicians and the clinicians who utilized it over a period of twelve months.

Materials and Methods

In this original study, 3D printing of the vanperio model which was custom built by 3D data with the help of software (Autodesk Meshmixer) and the 3D printer (fused deposition modelling) using desired material Polylactic Acid (PLA). An online feedback forms were sent to twenty five academician and clinicians who purchased the vanperio model within and outside India.

The steps in making of 3D Printed vanperio model (Figure 1A-1D) are 3D scanning (Figure 1A), 3D design (Figure 1B), 3D slicing (Figure 1C), 3D printing (Figure 1D).

The various purposes served by the vanperio model are presented in table A. They include patient education and motivation, pre surgical and surgical demonstration as listed in the table A.

In the patient education and motivation; the brushing, use of interdental brush (stim interdental brush by Global Dent Aids Pvt Ltd, India) and flossing demonstration were considered using vanperio model (Figure 2A-2E). The Plaster of Paris model (Figure 2B and 2D) depicted the non-possibility of interdental brushing and flossing demonstration. Pre-clinical (Figure 3A-3C) and periodontal surgical steps demonstration (Figure 4A-4H) were considered after the cotton cloth/mackintosh placement which depicted gingiva.

The academicians and clinicians who purchased the 3D Printed vanperio model sent their online feedback on the forms sent to them through their emails. The feedback forms were pertinent to patient education and motivation, student activities, student demonstration and overall presentation of the model considering its utility (Table B). The data obtained by the feedback forms were subjected to statistical analysis and the percentage expression was considered.

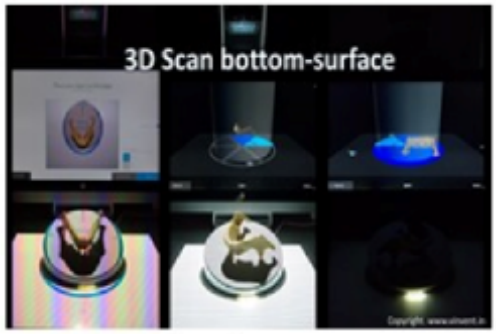

Figure 1A: *3D scanning.*

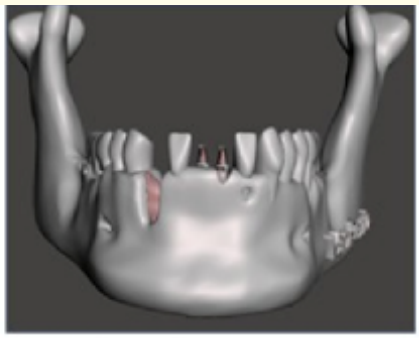

Figure 1B: *3D design*

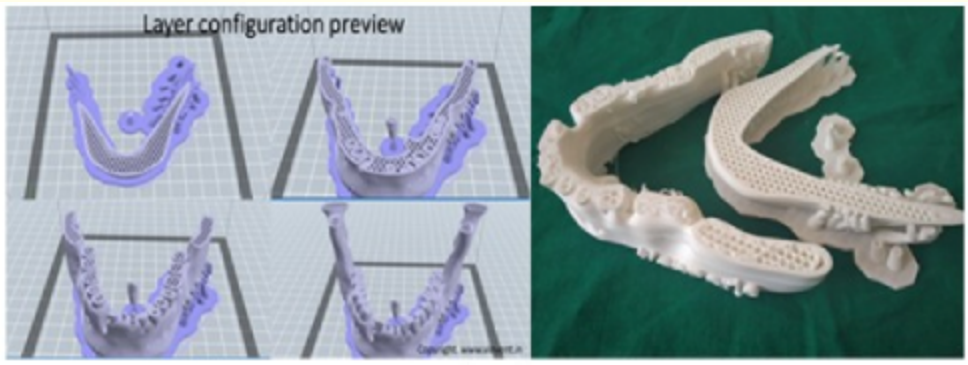

Figure 1C: *3D slicing.*

Figure 1D: *3D printing.*

Figure 1: *Steps in making of 3D Printed Vanperio model.*

Figure 2A: *Interdental brush placement on Vanperio model.*

Figure 2B: *Inability of interdental brush to enter interdental space.*

Figure 2C: *Use of floss on Vanperio model.*

Figure 2D: *Use of floss on Plaster of Paris model.*

Figure 2E: *Osseo integrated implant, immediate implant in alveolar socket.*

Figure 2: *Patient education and motivation.*

Figure 3A: *Scaling and root planning.*

Figure 3B: *Splinting.*

Figure 3c: *Probing technique.*

Figure 3: *Preclinical activity using 3D Vanperio model.*

Figure 4A: *During surgery-Direction of needle for Local anaesthesia administration.*

Figure 4B: *Placement of incision.*

Figure 4C: *Flap refection.*

Figure 4D: *Debridement.*

Figure 4E*: Placement of graft.*

Figure 4F: *Placement of GTR.*

Figure 4G: *Suturing.*

Figure 4H: *After suturing.*

Figure 4: *Presurgical activity using 3D Vanperio model.*

Patient education and motivation	Student activity and demonstration	
	Pre clinical	Pre surgical

• Demonstration of oral hygiene measures
  • Brushing
  • Use of Interdental brush
  • Flossing
• Treatment planning
  • Bone loss
  • Gum recession
  • Implants
	• Probing techniques
	• Non surgical procedures:
	• Hand scaling
	• Splinting
		• Direction of needle for Local anaesthesia administration
		• Surgical techniques (incisions, reflection of flap, debridement, Grafting techniques, use of Guided tissue regeneration, suturing)
		• Periodontal Osseous defects

Table A: *Purposes served by the Vanperio model.*

Categories	Criteria
1. Patient education and motivation a) Demonstration of brushing techniques b) Demonstration of interdental brushing c) Demonstration of flossing d) Demonstration of osseous defects	• Excellent • Good • Fair • Poor
2. Student activity A. Demonstration of Scaling and Root Planing B. Demonstration of Splinting C. Demonstration of Surgical Steps C1. Local Anaesthesia administration C2. Placement of Incision C3. Reflection of Flap C4. Access to Osseous Defect C5. Debridement C6. Placement of Osseous Graft C7. Placement of Guided tissue regeneration membrane C8. Suture Placement and closure of Flaps. C9. Practicing of Suturing Techniques at suture holes on the right side of the mandible	• Possible • Not possible

Student Demonstration 1. Normal/Positive bone architecture 2. Mental foramen 3. Mandibular foramen 4. Fenestration 5. Dehiscence 6. Negative bone architecture 7. Flat bone architecture 8. Horizontal Bone Loss 9. Two wall &Three-wall osseous defect 10. Buttressing bone (Lipping) 11. Furcation involvement Grade I 12. Furcation involvement Grade II 13. Furcation involvement Grade III 14. Marginal gutter 15. Hemi septum (with removable tooth) 16. Osseous Crater 17. Interdental space for Flossing technique (33,34) 18. Immediate implant in alveolar socket, Osseo-integrated implant 19. Suture holes 20. Enamel pearl 21. Exostosis. 22. Cancellous bone	• Well appreciated • Moderately appreciated • Least appreciated
4. Overall presentation of the model 1. Esthetic presentation 2a. Patient education 2b. Student demonstration 2c. Student activity	• Excellent • Good • Fair • Poor

Table B: *Assessment categories of Vanperio model.*

Results

There were two dropouts from total of twenty five clinicians who were non communicable despite the emails and telephonic messages from those who utilized the vanperio model for the academic purpose. The results of the study are presented (Table 1-4).

There are four responses assessed regarding patient education and motivation using vanperio model. The maximum response of 53.3% was marked for osseous defects demonstration, followed by demonstration of flossing and interdental brushing (47.8%) and brushing technique (30.4%). About 8.7% reported that demonstration of flossing and interdental brushing was not possible. The good and fair response were also marked. The response poor was not marked (Table 1).

Question numbers	Questions	Excellent (%)	Good (%)	Fair (%)	Poor (%)	Not possible (%)
1	Demonstration of brushing techniques	30.4	39.1	21.7	0	8.7
2	Demonstration of interdental brushing	47.8	39.1	4.3	0	8.7
3	Demonstration of flossing	47.8	39.1	4.3	0	8.7
4	Demonstration of osseous defects	52.2	34.8	13.	0	0

Table 1: *Patient education and motivation using VANPERIO model.*

For the student activity, whether the activity was possible and not possible response were assessed. Instruction brochure comprised of information to prepare the vanperio model for student activity. For surgical steps activity, placement of mackintosh/ cotton cloth as a representation of scalloped gingiva was suggested (Figure 3A-3C and 4B-4H). The suturing technique was possible at suture holes at the right molar area (Figure 4G). The scaling, Root planning and splinting activity was assessed as possible by 91.3% of vanperio users and 8.7% of the responses were not possible. In the surgical steps activity, a maximum of 100% of vanperio users assessed the access to osseous defects as possible where as local anaesthesia administration and suturing technique activity were assessed to be possible by 95.7% of vanperio users. In the descending order, other surgical steps activities were assessed. The assessment of not possible for debridement (30.4%), incision placement and reflection (26.1%) and suture placement and flap closure (13%). The local anaesthesia and suture activity were also assessed to be not possible (4.3%) (Table 2).

Question numbers	Questions	Possible (%)	Not possible (%)
A	Demonstration of Scaling and Root Planning (Use Sticky wax to simulate calculus deposit)	91.3	8.7
B	Demonstration of Splinting	91.3	8.7
C1	Local Anaesthesia administration	95.7	4.3
C2	Placement of Incision	73.9	26.1
C3	Reflection of Flap	73.9	26.1
C4	Access to Osseous Defect	100	0
C5	Debridement	69.6	30.4
C6	Placement of Osseous Graft (Plaster: Stone can be used)	91.3	8.7
C7	Placement of Guided Tissue Regeneration membrane	91.3	8.7
C8	Suture Placement and closure of Raps	87	13
C9	Practicing of Suturing Techniques at suture holes on the right side of the mandible	95.7	4.3

Table 2: *Student activity for periodontal treatment procedure using vanperio model.*

The periodontal osseous defects demonstration (Figure 5A-5L) was assessed as three responses: well appreciated, moderately appreciated and least appreciated. There were twenty two different types of periodontal related normal anatomic structures, disease induced osseous defects and additional features. Among them, maximum number of response (91.3%) towards well appreciated was given for demonstration of hemiseptum, osseous crater and exostosis and the minimum number of response (60.9%) was for cancellous bone. In the moderately appreciated group, maximum response of 34.8% was for cancellous bone and minimum response of 8.7% towards hemiseptum, osseous crater and exostosis. In least appreciated group, the maximum response of 8.7% was for two wall defect and three wall osseous defects (Table 3).

Figure 5A: *Dehiscence.*

Figure 5B: *Marginal gutter.*

Figure 5C: *Exostosis.*

Figure 5D: *One wall osseous defect.*

Figure 5E: *Two wall osseous defect.*

Figure 5F: *Enamel pearl on buccal root division area.*

Figure 5G: *Flat bone architecture.*

Figure 5H: *Mental foramen, buttressing bone (lipping) on marginal bone area between 44 and 45, horizontal bone lone on interdental between 44 and 45*

Figure 5I: *Positive bone architecture between 33, 34, 35.*

Figure 5J: *Grade 1 furcation involvement.*

Figure 5K: *Grade 2 furcation involvement.*

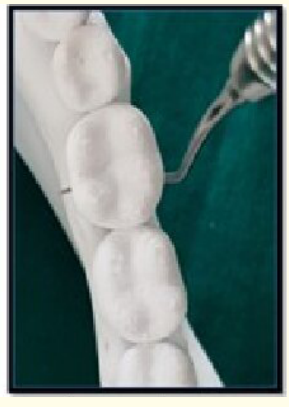

Figure 5L: *Grade 3 furcation involvement.*

Figure 5: *Periodontal osseous defects created in 3D Vanperio model.*

Question number	Questions	Well appreciated (%)	Moderately appreciated (%)	Least appreciated (%)
1	Normal / Positive bone architecture	69.6	30.4	0
2	Mental foramen	82.6	17.4	0
3	Mandibular foramen	87	13	0
4	Fenestration	73.9	26.1	0
5	Dehiscence	78.3	21.7	0
6	Negative bone architecture	87	13	0
7	Flat bone architecture	82.6	13	0
8	Horizontal Bone Loss	87	13	0
9	Two wall &Three-wall osseous defect	69.6	21.7	8.7
10	Buttressing bone (Lipping)	82.6	13	4.3
11	Grade I Furcation involvement	82.6	17.4	0
12	Grade II Furcation involvement	69.6	30.4	0
13	Grade III furcation involvement	69.6	26.1	4.6
14	Marginal gutter	78.3	21.7	0
15	Hemi septum (with removable tooth)	91.3	8.7	0
16	Osseous Crater	91.3	8.7	0
17	Interdental space for Flossing technique (33,34)	69.6	21.7	8.7
18	Immediate implant in alveolar socket, Osseo-integrated implant	73.9	21.7	4.3
19	Suture holes	69.6	30.4	0
20	Enamel pearl	87	13	0
21	Exostosis	91.3	8.7	0
22	Cancellous bone	60.9	34.8	4.3

Table 3: *Student demonstration of periodontal osseous defects using vanperio model.*

The overall presentation of the vanperio model were evaluated for esthetic presentation, patient education, student demonstration and student activity. The assessment criteria were excellent, good, fair and poor. The assessment was excellent (60.9%) for patient education and student demonstration. Further, the student activity and esthetic presentation received assessment as excellent in 56.5% and 39.1% of feedback. 56.5% of vanperio model users reported the esthetic presentation as good. The assessment was poor (4.3%) for student demonstration activity (Table 4).

Question number	Question	Excellent (%)	Good (%)	Fair (%)	Poor (%)
1	Esthetic presentation	39.1	56.5	4.3	0
2a	Patient education	60.9	34.8	4.3	0
2b	Student demonstration	60.9	30.4	4.3	4.3
2c	Student activity	56.5	34.8	8.7	0

Table 4: *Overall presentation of the VANPERIO model.*

Discussion and Conclusion

There are various models available which are made of different materials. The natural bone model for demonstration of osteology is the best model for teaching and learning. However, the availability of the bone models are not easy. The most commonly used dental models of upper and lingual arches are made of Plaster of Paris, stone, plastic and metal. The naturality of these dental models are compromised although they are economical. To surpass the problems associated with routine dental models there was a need to create a model which can be used for patient education and motivation, student demonstration activity and learning activity.

The patient education and motivation are the important tools for creating awareness and compliance towards periodontal treatment. The basic oral hygiene methods like interdental brushing and flossing were made possible in the 3D printed vanperio model by creating loss of contact between the teeth to allow the demonstration of interdental aids. The routinely used acrylic, Plaster of Paris and dental stone models didn't facilitate the option of interdental aids demonstration where in there was lack of naturality of teeth and jaws. The 3D printed vanperio model was able to elicit response such as excellent (52.3%) for demonstration of regular brushing and interdental aids. No time there was poor response for patient motivation and demonstration. About 9.7% of the vanperio model users felt that there patient demonstration was not possible as two instructions provided in the brochure was not considered by them. The authors provided the clarification to make better use of the model on a reply note.

The postgraduate curriculum in most of health universities recommend preclinical periodontal procedural exercises. Based on that requirement, the vanperio model provided most of commonly practised preclinical periodontal nonsurgical and surgical activity steps to simulate the natural 3D environment for learning. From the vanperio users, the response to access to osseous defects activity was 100% possible and least was for osseous debridement (69.6%). Except for osseous defects access, all the other student activities were assessed as not possible which was due to inadequate follow up of vanperio model instruction brochures which provided the methods to modify the vanperio model easily with zero to minimum expenditure to perform the student activity. The authors contacted the users to modify the vanperio model to help students learn the preclinical activities better.

The vanperio model provided the 3D view of maximum number of periodontal osseous defects for the first time in the periodontal literature. So far, the means of learning periodontal osseous defects was available in few of the periodontology related textbooks and color atlas which provided only two dimensional images. The student had better vision of periodontal osseous defects only on surgical exposure during open flap debridement. The 3D vanperio model overcame the shortcomings of two dimensional images and provided the excellent visualization of periodontal osseous defects. The clarification of number of walls of osseous defects as one wall, two wall and three wall was encouraging and fulfilling the learning curve.

The overall presentation of the model was assessed as the 3D printing of human mandible for teaching and learning activity was introduced for the first time in periodontal literature. All the four categories of feedback evaluation was found to be excellent patient education and student demonstration followed by student activity and esthetic presentation.

The advantages of vanperio model are, patient education and motivation like demonstration of interdental brushing and flossing which was not possible in the POP model; demonstration of maximum types of the osseous defects in one model; it is economical, light weight, easily washable and the anatomical structures can also be painted if required. The only drawback is that the material is breakable, so proper care has to be taken while handling. A recent review by KL Vandana., *et al.* has mentioned about the various techniques and applications of 3DP in dentistry and periodontics.

The 3D printing as an overall entity, helps in creating medical models that have undercuts, voids and complex internal geometries, such as neurovascular canals or sinuses. It is highly efficient, flexible and has a wide array of application in day to day life, in medicine and dentistry. However, the short comings of 3D printing are high cost of material, maintenance of material and need for a skilled operator.

Acknowledgement

We thank Dr. Abhishek, Vatsalya Invetures for the expertise in 3D printing unique, educative VANPERIO model based on the intellectual property of Dr Vandana KL.

Conflict of Interest

Nil.

Bibliography

1. Schubert C., *et al*. "Innovations in 3D printing: a 3D overview from optics to organs". *British Journal of Ophthalmology* 98.2 (2014): 159-161.
2. Klein GT., *et al*. "3D printing and neurosurgery-ready for prime time?" *World Neurosurgery* 80.3-4 (2013): 233-235.
3. Gross BC., *et al*. "Evaluation of 3D printing and its potential impact on biotechnology and the chemical sciences". *Analytical Chemistry* 86.7 (2014): 3240-3253.
4. Jain., *et al*. "Recent Trends of 3-D Printing in Dentistry- A review". *Annals of Prosthodontics and Restorative Dentistry* 2.4 (2016): 101-104.
5. Ruchir Patel., *et al*. "A New Leap in Periodontics: Three-dimensional (3D) Printing". *Journal of Advanced Oral Research* 8.1-2 (2017): 1-7.
6. Ravindra Babu Lakkaraju., *et al*. "Three-Dimensional Printing - A New Vista for Periodontal Regeneration: A Review". *International Journal of Medical Reviews* 4 (2017): 81-85.

Volume 18 Issue 12 December 2019