

Management of Non Healing Periapical Lesions with Surgical Endodontic Therapy Assisted with 3D Additive Manufacturing Aids: Case Series

Raji Viola Solomon^{1*}, MS Ranga Reddy¹, P Karunakar², Shanti Priya³ and Sravan Polasa⁴

¹*Professor, Department of Conservative Dentistry and Endodontics, Panineeya Institute of Dental Sciences and Research Centre, KNR University of Health Sciences, India*

²*Professor and Head of Department, Department of Conservative Dentistry and Endodontics, Panineeya Institute of Dental Sciences and Research Centre, KNR University of Health Sciences, India*

³*Senior Lecturer, Department of Conservative Dentistry and Endodontics, Panineeya Institute of Dental Sciences and Research Centre, KNR University of Health Sciences, India*

⁴*Post Graduate Student, Department of Conservative Dentistry and Endodontics, Panineeya Institute of Dental Sciences and Research Centre, KNR University of Health Sciences, India*

***Corresponding Author:** Raji Viola Solomon, Professor, Department of Conservative Dentistry and Endodontics, Panineeya Institute of Dental Sciences and Research Centre, KNR University of Health Sciences, Hyderabad, Telangana, India.

Received: March 14, 2019; **Published:** April 08, 2019

Abstract

The purpose of this article is to describe a novel conservative approach for the management of periapical surgery with the aid of 3D additive manufacturing technology. The incorporation of 3D printing in Endodontic surgical procedures is done to assist in more precision and to limit the extent of the surgical flap design to enable a favorable outcome and healing.

The patients presented in this case series required endodontic surgical intervention for resolution of the periapical pathology, which was decided as the final treatment plan after thorough case analysis and confirmation of diagnosis. Instead of the traditional approach to the surgical site and root end, an alternative approach to perform guided endodontic surgical access was outlined. All patients were informed and explained of the advantages of template guided surgery and gave their informed consent for the same. After routine and relevant diagnostic tests, all patients were sent for CBCT. The diagnostic data from CBCT scan is utilized to fabricate the physical model of the surgical site and a surgical template using 3D printing. The surgical template was used to design the flap and improve the visibility during the surgery. The template in addition served as a guide to the site of surgical access and was fabricated in a manner to retract the elevated flap and hold it stable in position. The patients were asymptomatic during follow up. On clinical and radiographic examination the healing was found satisfactory.

The utilization of 3d printing technology for surgical template fabrication aided in performing the surgery at an ease with improved isolation to the surgical site. In addition to serving as a soft tissue retractor, there was also improved visibility for root end manipulation. All these factors coupled together helped perform atraumatic soft tissue procedures which played a role in improving the outcome of treatment.

Keywords: 3D Printing; Guided Endodontic Surgery; Guided Osteotomy; Guided Root Resection; Surgical Template

Abbreviations

CBCT: Cone Beam Computed Tomography; CAD: Computer Aided Design; 3D: Three Dimensional; DICOM: Digital Imaging and Communications in Medicine; MTA: Mineral Trioxide Aggregate; PRF: Platelet Rich Fibrin; PRP- Platelet Rich Plasma; AAE: American Association of Endodontics

Citation: Raji Viola Solomon, *et al.* "Management of Non Healing Periapical Lesions with Surgical Endodontic Therapy Assisted with 3D Additive Manufacturing Aids: Case Series". *EC Dental Science* 18.5 (2019): 858-865.

Introduction

The principle behind endodontic surgery is to completely eradicate the periapical pathology and it is a challenging task for a clinician when the lesion involves a large anatomic area or when it is in close proximity to the vital structures [1]. The modern endodontic surgery has become very minimally invasive due to utilization of advanced armamentarium such as dental operating microscope, microsurgical instruments and biomimetic regenerative materials.

In this article focus on newer 3-dimensional aids like 3D printing is employed to assist in surgical endodontic procedures to facilitate favorable treatment outcomes. 3D printing is a term which is used to describe a manufacturing or fabrication process that forms a three-dimensional object by the addition or deposition of selected material layer by layer. It can also be described as additive manufacturing or rapid prototyping [2]. 3D printing technology was introduced by Dr. Charles Hull in 1984 and since then it has been in use bringing remarkable change in the way objects are made. There are several modalities and technologies in 3D printing like fused deposition modelling, stereolithography, photopolymer jetting, powder binder proteins, selective laser sintering etc [2]. The fused deposition modeling is the most commonly used technology among the above.

However, 3D printing has captured the public interest in recent years as it is an emerging field, showing propitious scope in areas of diagnosis and research. The implementation into the field of Medicine and Dentistry have brought tremendous improvements in diagnosis and treatment planning of various complex diseases and conditions. The Science of 3D printing has paved its way into all the branches of Dentistry in conjunction with the advanced diagnostic aids like cone beam computed tomography or any other preferred digital imaging technology. Applications of 3D printing in Conservative Dentistry and Endodontics include production of physical diagnostic models, fabrication of inlays, onlays and crowns, manufacturing of Endodontic guides, presurgical case assessment models, templates and guides for periapical surgeries etc.

Compared to conventional surgery 3D printed surgery has many advantages like conservative flap design, minimal osteotomy, less invasive root end preparation procedures there by influencing faster healing rates [3,4]. This is possible as the surgical site is printed by virtual design into a graspable physical model allowing the operator to better visualize the area of concern. This case series describes the management of 3 surgical endodontic procedures utilizing the novel 3-dimensional approach of 3D printing to improve the presurgical case assessment, isolation, soft tissue retraction and endodontic guide for flap design and osteotomy. All the treated patients have a follow up period of 2 years and presented with untoward clinical and radiographic findings.

Case Report-1

A 26-year-old female patient presented to Department of Endodontics, Panineeya Institute of Dental Sciences with the chief complaint of swelling and discomfort in upper front tooth region. The clinical examination revealed discolored teeth in relation to 21, 22. It was non tender to percussion with mild history of pain. Patient presented with recurrent swellings which were subsided only by medication. The swellings would recur after few weeks on discontinuation of medication. Patient gave a history of trauma 5 years back. Upon radiographic examination a large periapical lesion extending over 21, 22, 23 was observed. The involved teeth tested negative to routine diagnostic tests. The patient was advised CBCT for complete diagnostic evaluation and gave informed consent for the same. CBCT (HDX WILL, KOREA pixel size 1326*1312.1024*1024) revealed a large lesion of size 5*7 mm in the anterior maxillary region pertaining to the teeth 21, 22, 23 (Figure 1a-1e). The diagnosis was tentatively confirmed as non vital teeth in 21, 22, 23 with periradicular lesion and it was decided to treat by conventional root canal therapy irt 21, 22, 23 (Figure 1f) followed by periradicular surgery. A presurgical model for the assessment of size and extent of the lesion was fabricated using 3D printing (Figure 1g-1j). Upon examination of the 3D model the surgical template was designed using CAD software.

The periapical surgery was performed using both the pre surgical model and the surgical template (Figure 1o-1p). The presurgical model helped in understanding the extent of the pathology. The template served in designing the extension of the flap around the lesion [4,5]. The 3D Template is fabricated with a window that extends 2 mm around the lesion for improved visibility to provide optimal access to the surgical site for osteotomy. The lesion was completely curetted and root apices were exposed [3]. As the template extended 2 mm below the root apices, the identification of the same was facile and the root resection was performed using long length surgical burs (prima classic Hp 702). After the resection of root tips the retro preparation was carried out using piezoelectric ultrasonic tips (ProUltra tip-size2) to a depth of 3 mm and prepared cavities were filled with MTA (Figure 1q). Then the surgical site was closed with PRF and hydroxyapatite bone graft was packed in to the defect (Figure 1r). The PRF was prepared in a centrifuge by collecting 10 ml of blood from

median cubital vein of the patient and placed at the surgical site the flap was sutured back (Figure 1s and 1t). Postoperatively the patient was advised to apply cold pack intermittently for 2 hours to reduce the post surgical swelling. Post surgical instructions and medication were given. patient is asked to report after 24 hours. On 1 day recall there were minimal post operative symptoms. On 1 week recall complete epithelisation occurred with no soft tissue defects and the healing was found satisfactory (Figure 1u and 1v). Patient was recalled at 3 months, 6 months, 1 year and 2 years for evaluation of clinical and radiological healing and it was found to be satisfactory (Figure 1w-1y). On clinical periodic follow up evaluation throughout the 2 year period the patient remained asymptomatic without any complications. On radiographic examination considerable bone formation was evident obliterating the defect suggestive of osseous healing.

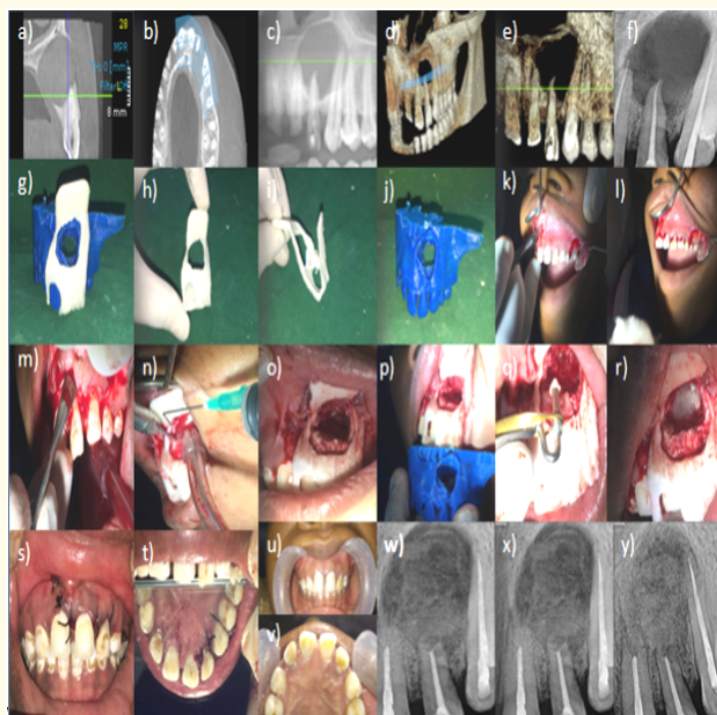


Figure 1: a) CBCT sagittal view, b) CBCT coronal view, c) CBCT frontal view, d) CBCT image showing size of the lesion, e) CBCT image -lateral view, f) Root canal treatment, g) Template on model, h) Template, i) Template-lateral view, j) Replica of the site, k) Incision, l) Flap design, m) Flap reflection, n) Osteotomy, o) Complete curettage, p) Comparison of lesion size on model and patient, q) MTA placement in retro cavity, r) PRF placement, s) Suturing frontal view, t) Suturing palatal view, u) Soft tissue healing on 1 week follow up -frontal view, v) Soft tissue healing 1 week follow up- palatal view, w) 3 month follow up, x) 6 month follow up, y) 2 years follow up.

Case Report-2

A 23-year-old female patient presented to Department of Endodontics, Panineeya Institute of Dental Sciences with the chief complaint of discomfort and swelling in upper front tooth region. Clinical examination revealed discolored teeth in relation to 21, 22. On vitality testing the teeth gave a negative response. Patient gave history of trauma during her childhood. Upon radiographic examination there was a large periapical lesion extending over 21, 22. The patient was advised CBCT for complete diagnostic evaluation. Cone beam computed tomography revealed a large lesion of size 4*6 mm in the anterior maxillary pertaining to the teeth 21, 22 (Figure 2a-2f). A presurgical model for assessment of the size and extent of the lesion was fabricated using 3D printing from DICOM files obtained with CBCT scan. A surgical template made of polylactone was then designed using CAD software and then fabricated using 3D printing (Figure 2g-2j). The surgery was performed using both the 3D printed pre surgical model as a reference and the surgical template as a guide to the site of the defect (Figure 2k-2p). Clinical and radiological healing was observed at the end of 1 year and 2 year recall period (Figure 2q-2u). The patient was informed to revisit once in 6 months for maintenance and further follow up.

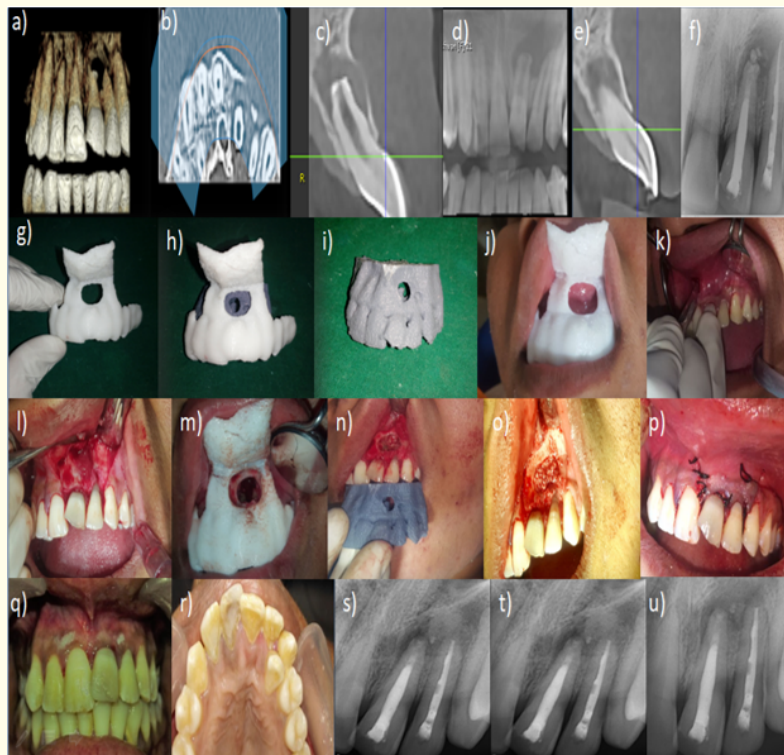


Figure 2: a) CBCT inverted mode, b) CBCT coronal view, c) CBCT sagittal view, d) CBCT frontal view, e) Lesion size on lateral incisor, f) Root canal treatment, g) Template, h) Template on model, i) Replica of the lesion site, j) Fit of the template over the surgical site, k) Incision, l) Flap reflection, m) Osteotomy, complete curettage, n) Comparison of lesion size on model and patient, o) PRF and bone graft placement, p) Suturing, q) Soft tissue healing on 1 week follow up- labial view, r) Soft tissue healing on 1 week follow up-palatal view, s) 1 month follow up, t) 6 month follow up, u) 2 years follow up.

Case Report-3

A 25-year-old male patient presented to Department of Endodontics, Panineeya Institute of Dental Sciences with the chief complaint of pain in upper front tooth region. On clinical examination there was discolored teeth in relation to 11, 12. It was non tender to percussion with recurrent swellings and radiating type of pain. Patient gives history of trauma during childhood. On radiographic examination there was a large periapical lesion extending over 11, 12. So the patient was advised CBCT for complete diagnostic evaluation. Cone beam computed tomography revealed a large lesion of size 8*11 mm in the anterior maxillary region pertaining to the teeth 11, 12 (Figure 3a-3d). Following root canal therapy irt 11, 12 (Figure 3k and 3l) surgical profile was obtained from the patient subsequent to which the surgical treatment was planned. A surgical template is designed using surgical planning software and then fabricated using 3D printing from the obtained DICOM files from CBCT scan (Figure 3e-3j) [4]. Then the surgery was performed using both pre surgical model and surgical template (Figure 3m-3u). The patient was subjected to systematic re evaluation for a period of 2 years and is still under observation (Figure 3w-3z). The entire follow up period was uneventful suggestive of successful outcome of therapy.

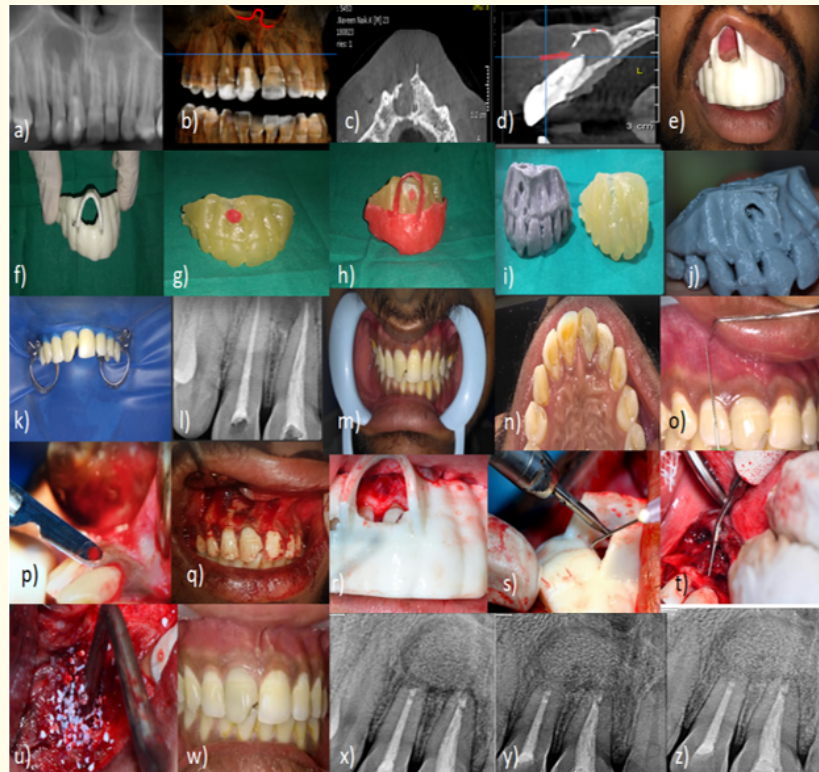


Figure 3: a) CBCT frontal view, b) CBCT inverted mode, c) CBCT coronal view, d) CBCT sagittal view, e) Fit of surgical template on patient, f) Template, g) Replica of the lesion marked in wax, h) Design of the template in modeling wax, i) Replica of the site in clear and colored resin, j) Replica of the site showing lesion size, k) Isolation, l) Root canal treatment, m) Presurgical clinical picture, n) Palatal view-presurgical, o) Assessment of the lesion by taking a radiograph, p) Incision, q) Flap reflection, r) Template over the surgical site, s) Osteotomy, t) Retro preparation, u) Bone graft application, v) 1 week follow up showing soft tissue healing, w) 3 month follow up, x) 6 months follow up, y) 2 years follow up.

Discussion

The treatment option for large nonhealing periapical cysts varies depending up on the size and extent of the lesion and it is important to note the adjacent vital structures to prevent the possibility of damaging them during the procedure [6]. In conventional endodontic surgery, it is challenging to the clinician to exactly limit the extension of the surgical site, to maintain atraumatic reflection of the flap and to precisely identify the root apices [7,8].

In this series of case reports, 3D printing technology aided to overcome these challenges by enabling the clinician to carefully examine on table top the 3D reconstructed jaw [9]. Information regarding the size, location, involvement of cortical plates, juxtaposition of the involved root apices and their proximity to anatomical structures was easily obtained from the physical 3D model, which would not have been possible with routine radiographic examination [10]. Guided endodontic surgery has become an advanced treatment option as it reduces tissue damage which occurs through inadvertent extension of the osteotomy site during surgical procedure [3]. With the diagnostic data available from a CBCT scan, it is possible to transform it into a DICOM file by using the digital software design program. The use of CBCT for complete diagnostic evaluation was useful in assessing the anatomical structures [11]. Compared to conventional surgery 3D printed surgery requires additional time and the cost factor is also comparatively higher. However the productivity will be ultimately improved with the 3D printing surgery as there is preservation of bone due to exact extension of template over the lesion and also the other factors like precise flap reflection and root end resection. This contributes to the enhanced healing and favourable outcome of the procedure. This justifies the use of 3D assisted endodontic surgery.

Recently 3D printed templates have been in use for gaining access to calcified canals in anterior teeth through guided endodontic access [12]. This present case series assisted in understanding the extent of the defect for better management of guided endodontic surgery. Two Presurgical models made of polylactone material are fabricated by fused deposition modelling. One model is used for synthesizing diagnostic data [13] and the other model for designing the template. The design of the template was done by extending 2 mm around the lesion and the design was explained to the 3D printer lab personnel by wax mock up design [14]. Polylactone was the material of choice as it has good mechanical properties, low melting point and good adaptation to the tissues. For mock up design modelling wax was chosen as it has adequate rigidity and moldability to create the design which is desired by the clinician [4].

Physical models are very much useful in assessing the size and extent of the lesion more clearly than a CBCT scan which helps only in interpretation of virtual data [15]. Errors in virtual data analysis could be minimised when the viewer can visualise the physical 3D replica. A case study investigated by Bahcall JK, *et al.* [16] reported that CBCT has helped to improve case assessment by presurgical 3-D models created from the CBCT scan with the help of 3D printing. As per current guidelines of AAE, CBCT could be helpful in presurgical assessment of cases with periapical pathosis where the patient presents with nonspecific clinical signs with inadequate anatomic detailing observed in conventional imaging due to superimposition of other maxillofacial structures. Three-dimensional imaging will be helpful in assessment of relationship of root apices to other anatomical structures such as inferior alveolar canal, mental foramen, maxillary sinus in various planes [17]. Utilizing the information from the CBCT scan the clinician has expressed to the 3D printing lab personnel, how the desired template should be contoured. 3D printed template is fabricated covering the extremities of the defect and was verified clinically as it could be placed intraorally. It is verified on the patient prior to initiation of the surgical procedure. The template was modified according to the fit on the patient and it was sterilized in the formalin chamber before the surgery.

Subsequent to the intraoral positioning of the template the soft tissue flap design was planned. Additional benefit of using the template was that after the flap was elevated, it served to retract the elevated flap. No additional retraction was required and the raised flap was stabilised with ease. This prevented further soft tissue manipulation which is the major contributing factor for healing outcomes. This is in accordance with the findings of Patel S, *et al.* [4] who also concluded that custom 3D-printed soft tissue retractor improved access to the surgical site and minimized soft tissue damage. Strbac GD, *et al.* [3] in their study found that the surgical guide may allow for a consistently accurate and reliable access to the apex of a root by minimizing the risks of damaging vital structures.

MTA was chosen as the material for retrofilling as it is the best material which enhances hard tissue deposition in direct contact with the tissues. Von Arx T, *et al.* [18] in their investigations reported high and constant success rates of teeth treated with MTA in apical surgery. The osteotomy site was packed with PRF as it is an adjunctive to promote the acceleration of healing and reduce post operative discomfort [19]. In present case series, on 1 week recall complete epithelisation occurred with no soft tissue defects and the healing was found satisfactory for all the treated surgical cases. In the present case series all the bony defects were packed with PRF and bone graft. The reason behind choosing PRF over PRP is as it has growth components and it acts as a scaffold for bone formation. It is an autologous preparation and has proven credibility and is cost effective. This is in accordance to the research by Mazumdar P, *et al.* [19] who concluded that the PRF is effective as it promotes faster clinical and radiological healing when used in intrabony defects in case of periapical surgeries. Angerame D, *et al.* [20] in their study also concluded that the application of PRF in to surgical site helps not only in better healing but also it reduces the postoperative discomfort. PRF stimulated the formation of bone within 2 to 3 weeks of time as evidenced radiographically. The use of soft tissue template served in flap design, soft tissue retraction, visibility, guided osteotomy, root end resection and preparation. Endodontic surgeries performed with the aid of these 3D printed surgical templates and models will definitely have an added advantage over conventional surgeries where the exact extent of the lesion and localisation of vital structures may not be possible.

However more insight into the arena of 3D printing is required to understand the applications and advantages of it in the field of endodontics. More clinical longterm trials are required to confirm the findings of the present case series.

Conclusion

- 3D printed presurgical models fabricated by using DICOM files served in assessing the size, extent of the lesion and adjacent structures more accurately.

- In addition the physical 3D model helped to design a 3D printed template which the clinician customised according to the size of the analyzed defect. During the surgical procedure the 3D guide helped the clinician with ease of soft and hard tissue manipulation.
- Regular follow ups were performed up to 24 months which showed satisfactory results in all the treated cases.
- In this case series positive results were obtained to manage large nonhealing periapical lesions assisted with 3D additive manufacturing aids for surgical Endodontics.
- Within the limits of the observations it can be concluded that the application of 3D printing in surgical endodontics is highly beneficial showing propitious scope over traditional approaches.

Financial Support

Nil.

Conflict of Interest

Nil.

Bibliography

1. Anderson J., *et al.* "Endodontic applications of 3D printing". *International Endodontic Journal* 51.9 (2018): 1005-1018.
2. Dawood A., *et al.* "3D printing in dentistry". *British Dental Journal* 219.11 (2015): 521-529.
3. Strbac Georg D., *et al.* "Guided modern endodontic surgery: a novel approach for guided osteotomy and root resection". *Journal of Endodontics* 43.3 (2017): 496-501.
4. Patel S., *et al.* "A novel method for soft tissue retraction during periapical surgery using 3D technology: a case report". *International Endodontic Journal* 50.8 (2017): 813-822.
5. Liu Yun-feng., *et al.* "Technical procedures for template-guided surgery for mandibular reconstruction based on digital design and manufacturing". *Biomedical Engineering Online* 13.1 (2014): 63.
6. Kim Syngcuk and Samuel Kratchman. "Modern endodontic surgery concepts and practice: a review". *Journal of Endodontics* 32.7 (2006): 601-623.
7. Tsesis Igor., *et al.* "Outcomes of surgical endodontic treatment performed by a modern technique: an updated meta-analysis of the literature". *Journal of Endodontics* 39.3 (2013): 332-339.
8. Rubinstein Richard A and Syngcuk Kim. "Short-term observation of the results of endodontic surgery with the use of a surgical operation microscope and Super-EBA as root-end filling material". *Journal of Endodontics* 25.1 (1999): 43-48.
9. Jung Ronald E., *et al.* "Computer technology applications in surgical implant dentistry: a systematic review". *International Journal of Oral and Maxillofacial Implants* 24 (2009): 92-109.
10. D'haese Jan., *et al.* "Accuracy and complications using computer-designed stereolithographic surgical guides for oral rehabilitation by means of dental implants: a review of the literature". *Clinical Implant Dentistry and Related Research* 14.3 (2012): 321-335.
11. Krastl Gabriel., *et al.* "Guided endodontics: a novel treatment approach for teeth with pulp canal calcification and apical pathology". *Dental Traumatology* 32.3 (2016): 240-246.
12. Zehnder MS., *et al.* "Guided endodontics: accuracy of a novel method for guided access cavity preparation and root canal location". *International Endodontic Journal* 49.10 (2016): 966-972.
13. Kühn Sebastian., *et al.* "Technical Accuracy of Printed Surgical Templates for Guided Implant Surgery with the co D iagnosti X TM Software". *Clinical Implant Dentistry and Related Research* 17.1 (2015): e177-e182.

14. Giacomino C Michelle., *et al.* "Targeted Endodontic Microsurgery: A Novel Approach to Anatomically Challenging Scenarios Using 3-dimensional-printed Guides and Trephine Burs-A Report of 3 Cases". *Journal of Endodontics* 44.4 (2018): 671-677.
15. Ye Shangzhu., *et al.* "A novel method for periapical microsurgery with the aid of 3D technology: a case report". *BMC Oral Health* 18.1 (2018): 85.
16. Bahcall James K. "Using 3-dimensional printing to create presurgical models for endodontic surgery". *Compendium of Continuing Education in Dentistry* 35.8 (2014): e29-e30.
17. Chandra Anil., *et al.* "Applications of CBCT in Surgical Endodontics-A Case Series". *Annual Research and Review in Biology* 20.4.
18. Von Arx T. "Mineral trioxide aggregate (MTA) a success story in apical surgery". *Swiss Dental Journal* 126.6 (2016): 573-595.
19. Mazumdar Paromita., *et al.* "Treatment of periapical lesion with platelet rich fibrin". *Indian Medical Gazette* (2013): 28-33.
20. Angerame Daniele., *et al.* "Application of platelet-rich fibrin in endodontic surgery: a pilot study". *Giornale Italiano di Endodonzia* 29.2 (2015): 51-57.

Volume 18 Issue 5 May 2019

©All rights reserved by Raji Viola Solomon., *et al.*