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DENTISTRY THROUGH 3D GLASSES

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JCSP 45

Exercise Solo Flight

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DENTISTRY THROUGH 3D GLASSES

By Major Domenico Belcastro

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DENTISTRY THROUGH 3D GLASSES

INTRODUCTION

The process to introduce any new technology into the Canadian Armed Forces can be lengthy at times when compared to organisations in the private sector. The advances' in Three-Dimensional (3D) Technology in the field of dentistry has steered the direction of the conversation in the CAF on how to best implement this technology in the Royal Canadian Dental Core (RCDC). One would compare the RCDC as an organisational group practice and like most legitimate organisation, the introduction of new equipment can only occur once the technology has been assessed to meet the needs of the institution.

Three-Dimensional (3D) Technology in recent years has become more prevalent in all aspects in the dental field and is predicted to replace current technology in the clinics in the foreseeable future. The equipment currently being looked at by the RCDC is Cone Beam Computed Tomography (CBCT), Intraoral Scanners (IOS) and three-dimensional dental printing.

Cone Beam Computed Tomography (CBCT) has recently become one of the favoured three-dimensional imaging techniques in the dental community to date. There are many benefits of CBCT over Two-Dimensional (2D) Imaging techniques currently being used in the RCDC and the private sector. In the past, the financial resources required to obtain this technology had limited the ability of the average dental clinic to procure this equipment. This seems to be no longer the case as the cost of obtaining a CBCT unit has dramatically decreased in price and is more or less comparable to the price of current 2D technology.

Another 3D advancement in the field of dentistry is the ability to digitally scan a patient's dentition to create a digital model in the virtual environment.¹ In recent years with the advent of new generation of Intraoral Scanners (IOS), the technology has made it easier and faster to collect and store digital images of a patient's dentition.²

Last of the 3D technology to be discussed is Three Dimensional (3D) printing. Three Dimensional (3D) printing is the processes of rapid prototyping of an object where the object is formed by adding layers on top of each other one at a time.³ By incorporating scans from both CBCT and Intraoral Scanners (IOS) the end user can design objects in a virtual environment and then fabricate a replica of that object with the use of a 3D printer.⁴

As obsolete equipment becomes life cycled out of the organisation, the procurement priorities along with other competing projects that are currently on the table will need to be re-evaluated. The future needs of the organisation must be defined in order to determine the value of acquiring this new technology over the status quo.

The basic concepts, advantages and applications of 3D technology in the field of Forensic Dentistry, Operative Dentistry, and Oral Maxillofacial Surgery will be reviewed along with the possible disadvantages of implementing this technology in the CAF. The intent of this review is to provide an insight on the benefits of embracing Three-Dimensional (3D) Technology into the Royal Canadian Dental Core (RCDC).

¹ Mithun Rajshekar et al, "*The Reliability and Validity of Measurements of Human Dental Casts made by an Intra-Oral 3D Scanner, with Conventional Hand-Held Digital Callipers as the Comparison Measure.*" *Forensic Science International* 278, (Sep, 2017a): 199.

² Ibid.

³ A Dawood et al, "*3D Printing in Dentistry.*" *British Dental Journal* 219, no. 11 (Dec, 2015a): 522.

⁴ Ibid.

BACKGROUND

The last decade has seen huge advancements in breakthrough technologies in the field of dentistry. These innovations in part are due to the rapid development of computer technology and computer-aided design (CAD) software over the past decade. Both the Dental and the Oral and Maxillofacial Surgery (OMFS) community have enthusiastically embraced this emerging technology and in some cases the use of this technology has become the standard of care in the treatment of patients. The attraction of this technology in the dental community in part comes from the common output or volumetric data that can be captured and the ability to use this data on different platforms. Technology innovations today affords the dental community the ability to have a cost effective means of obtaining data which can be then used by Computer-Aided Design (CAD) software available today to dentists around the world.

One of the most important technological advancements embraced by the dental community in the past decade was CBCT. Due to its compressed size, reduced cost, and low ionizing radiation exposure, CBCT now enables the practitioner to develop treatment strategies that were unattainable in the past due to the limitations of 2D radiography.⁵

Unlike conventional Computed Tomography (CT) radiography, a CBCT unit uses a cone-shaped x-ray beam along with a reciprocating solid state flat panel detector to capture an image.⁶ One scan captures multiple 2D images which are offset marginally from one another. 3D imaging software is then used to reconstruct the captured 2D images into a 3D representation of the anatomic structure for viewing. This image is then

⁵ Elluru Venkatesh et al, "*Cone Beam Computed Tomography: Basics and Applications in Dentistry.*" *Journal of Istanbul University Faculty of Dentistry* 51, no. 3 Suppl 1 (2017):104.

⁶ Ibid.

stored in a Digital Imaging and Communications in Medicine (DICOM) format and can be viewed anytime using “off the shelf” third party imaging software.⁷

Intraoral scanners (IOS) are other innovative devices that are used in dentistry for the capturing of a digital impression of a patient’s dentition.⁸ An intraoral scanner accomplished this by projecting a light source onto an object and then capturing this source using imaging sensors on the device.⁹ This information is processed by 3D scanning software which generates point clouds that can be used to create a 3D virtual model of the structure and surrounding tissues.¹⁰

3D printing represents another breakthrough technology that could have the potential to become a disruptive technology in the organisation. 3D printing or additive manufacturing is commonly used to describe a fabrication process that rapidly prototypes an object one layer at a time to create a copy of that object.¹¹ Without the recent advances in Cone beam computed tomography (CBCT), intraoral scanners (IOS) and Computer-aided design (CAD) software, additive manufacturing would not be possible today.¹² This technology now enables the end-user to design objects in the virtual environment from the data collected from different 3D technologies and “print” a copy of that object with just a push of a button.¹³

There are many in the dental profession that have seen the potential of 3D technologies and have already become early adopters of its use. The view of this author

⁷ Elluru Venkatesh et al, "*Cone Beam Computed Tomography: Basics and Applications in Dentistry.*" Journal of Istanbul University Faculty of Dentistry 51, no. 3 Suppl 1 (2017):104.

⁸ Francesco Mangano et al, "*Intraoral Scanners in Dentistry: A Review of the Current Literature.*" BMC Oral Health 17, no. 1 (Dec 12, 2017): 2.

⁹ Ibid.

¹⁰ Ibid.

¹¹ A Dawood et al, "*3D Printing in Dentistry.*" British Dental Journal 219, no. 11 (Dec, 2015a): 521.

¹² Ibid.

¹³ Ibid.

is that the organisation at large should not underestimate the potential of this technology as it becomes more main stream in the dental profession.

FORENSICS DENTISTRY

The legitimacy of a society can be demonstrated by the importance that the society places on identifying their deceased. An awareness that all members have in the military is the understanding that they could be eventually put into harm's way in the performance of their duty. With this understanding comes the obligation of the Canadian Armed Forces to be able to identify and return the bodies of fallen soldiers back to love ones. Even though the events of a disaster may share common elements, the identification of a single person or multiple people from a disaster can be both simple and complex in nature.¹⁴ Dr David Sweet (DABFO), a certified specialist in forensic odontology, defines comparative dental identification as the comparison of dental structures of a body post-mortem (PM) to that of records ante mortem (AM) to determine if there is a match with a person of interest.¹⁵ Teeth being one of the hardest structures in the human body are usually one of the primary structures that survive a violent disaster.¹⁶ The use of radiographs to help identify a person has been used for many years and has been proven to be both reliable and effective.¹⁷ Forensic odontologists have recognized the value that radiography brings to the table in forensic dentistry but have noted that there is no single correct methodology for ante mortem and post mortem radiography.¹⁸ Forensic odontologists utilize dental radiography to provide documentation of anatomic structures

¹⁴ David Sweet, "Forensic dental identification", *Forensic Science International* 201, no. 1 (2010) 3.

¹⁵ *Ibid.*

¹⁶ *Ibid.*

¹⁷ R.E. Wood and S.L Kogon, "Dental Radiology Considerations in DVI Incidents: A Review." *Forensic Science International* 201, no. 1 (2010a): 27.

¹⁸ *Ibid.*

post mortem which can then be used to compare against ante mortem images.¹⁹ The availability of analog radiographic images, 2D digital radiography and more recently 3D digital radiography, provides forensic odontologists more flexibility when choosing an apparatus to be used for a specific case which is the key to the identification process.

There are many advantages of 2D/3D digital radiography over conventional “wet film” radiography. These include not having to follow strict film mounting position, do not require any chemistry to process a film, image acquisition is instantaneously, image can be digitally enhanced, duplicates can be easily made, and a digital file can be sent around the world in seconds for further consultation.²⁰

The quality and quantity of ante mortem (AM) information available to compare to post-mortem (PM) structures is essential to properly and confidently identify a person. Even when one looks at the options available to conduct ante mortem and post-mortem identification, an argument can be made that there is more information available from CBCT radiography verses conventional 2D radiography. As one would expect when trying to overlay post-mortem records onto ante mortem records, the more information that is available for a forensic odontologists, the great the ability to positively identify a person.

An example is seen from the study conducted by Williams A Franco on the uniqueness of the human dentition (UHD).²¹ In his study, Franco commented on how 3D comparison of maxillary and mandibular dental casts can be used to positively and accurately identify post mortem anatomic structures from dental cast of a missing person examined ante

¹⁹ R.E. Wood and S.L Kogon, "Dental Radiology Considerations in DVI Incidents: A Review." *Forensic Science International* 201, no. 1 (2010a): 28.

²⁰ *Ibid*,31.

²¹ Franco, A.|Willems, G.|Souza, P.H.C.|Tanaka, O.M.|Coucke, W.|Thevissen, P. "Three-Dimensional Analysis of the Uniqueness of the Anterior Dentition in Orthodontically Treated Patients and Twins." *Forensic Science International* 273, (2017): 86

mortem (AM).²² The information provided from a CBCT scan could be used to 3D map the uniqueness of anatomic structures such as tooth structure. There could come a time where the uniqueness of the human dentition (UHD) such as the pulp chamber of a tooth or the root of a tooth could be used to positively identify a missing person post mortem.²³ This would not be possible with conventional 2D radiography used today.

Similarly, the use of Intraoral Scanners (IOS) in forensic investigations has excellent potential in the field of forensic dentistry that has yet to be explored.²⁴ The new generation of Intraoral Scanners (IOS) have the potential to allow forensic odontologists the ability to gather and save digital images of a large numbers of dentitions on a laptop or portable hard drive.²⁵

Several studies have compared virtual models created by 3D scanners to models fabricated from stone. The results obtained in these studies concluded that virtual models were equally as accurate and reliable as those fabricated the conventional way.²⁶ There are many down sides to traditional methods of fabricating casts. Casts made from stone are bulky and heavy and will undergo structural changes over time that may lead to geometrical inconsistencies.²⁷ The matter of long term storage of thousands of cast accumulated over a decade of time is also a problem that can be overcome with 3D virtual casts.²⁸ The availability of having access to virtual casts along with digital radiographs

²² Franco, A.|Willems, G.|Souza, P.H.C.|Tanaka, O.M.|Coucke, W.|Thevissen, P. "Three-Dimensional Analysis of the Uniqueness of the Anterior Dentition in Orthodontically Treated Patients and Twins." *Forensic Science International* 273, (2017): 86

²³ Ibid.

²⁴ Mithun Rajshekar, The reliability and validity of measurements of human dental casts made by an intra-oral 3D scanner, with conventional hand-held digital callipers as the comparison measure, 199.

²⁵ Ibid.

²⁶ Ibid.

²⁷ Ibid.

²⁸ Ibid.

would provide forensic odontologists with the quality and quantity of information required to identify a persons at their fingertips.

The introduction of these breakthrough technologies into the organization could be seamless as outdate equipment starts to be life cycled out of the institution. A business case could be made in the replacement of conventional panorex units with CBCT units and intra-oral 3D scanners.

The new advances in technology could fundamentally change several of the processes in the organization. New recruits and current patients could have a forensic dental examination that would contain a 3D radiographic image along with a digital image of their dentition. The information contained in this record would be far superior to that of current 2D charting being used and would take a fraction of the time to obtain. Once in the forensic record of the patient digital chart, this information could be called upon at any time, at any place around the world when required. This information would be of immense value to forensic identification and can similarly be made available to other dental and medical disciplines in the institution.

OPERATIVE DENTISTRY

Not unlike the field of forensic dentistry, three-dimensional technology could similarly influence the way clinicians practice operative dentistry and be introduced to reduce expenses in the organisation.

An example of this can be demonstrated in the way digital dentistry has revolutionized the manner in which clinicians and laboratories communicate together. Chair-side optical impression using Intraoral Scanners (IOS) have been available for well over a decade and

are considered to be a reliable alternative to conventional impressions for the fabrication of a wide variety of dental appliances.²⁹

It was not just too long ago that making an impression involved tray selection, and intra oral impression using an impression material, and shipping this impression to a laboratory for processing.³⁰ This process was furthermore complicated with patients who have allergies to the impression material being used or would have a strong gag reflex. The treatment options available to these patients were limited due to their inability to tolerate conventional impressions.

Unlike conventional impressions, digital impressions are digitally generated and are well-tolerated by the patient with allergies and a strong gag reflex.³¹ They provide greater efficiency and can be digitally stored and transferred electronically.³² With the information provided from a digital model, a dentist or laboratory technologist is now able to design a dental appliance in the virtual environment from start to finish with the aid of computer-aided design (CAD) software.³³

Intraoral Scanners (IOS) could be used to streamline organisational processes in the way that dentistry can be provided to patients. A scan taken for patient treatment can be immediately evaluated and retaken without having to physically fabricate a plaster model.

²⁹ Mithun Rajshekar, The reliability and validity of measurements of human dental casts made by an intra-oral 3D scanner, with conventional hand-held digital callipers as the comparison measure, 198.

³⁰ Paulo Riberio, Accuracy of Implant Casts Generated with Conventional and Digital Impressions—An In Vitro Study, Published: 27 July 2018, 2.

³¹ Ibid.

³² Ibid.

²⁹ Mithun Rajshekar, The reliability and validity of measurements of human dental casts made by an intra-oral 3D scanner, with conventional hand-held digital callipers as the comparison measure, 198.

This process could have the potential to save clinical resources, time and improve the overall patient experience during treatment.³⁴

The ability of storing a digital impression in a patient's electronic file would have several benefits including reducing the physical space required to store patient casts within the clinic. The organisation would be able to save on the resources required to purchase of dental impression materials, impression trays, and on the time required to fabricate models.³⁵ In an operational environment there would be a great advantage in having a 3D scan of a patient's dentition available in the patient's electronic record. Once a scan has been obtained during an initial examination it could easily be stored in a patient electronic record indefinitely until called upon in any operational environment the patient may be within.

Additional benefits to the Canadian Armed Forces would be in the reduction of costs, increased speed of manufacture, and the ability to provide less invasive treatment options for patients.³⁶

This also holds true to 3D printing technology. The ability to 3D print restorations, stents, guides, and appliances could have the potential to save thousands of dollars as the organisation would not have to be as dependent on the private sector for the procurement of resources. Due to recent technological advances, 3D printing would not be just limited to materials such as polymers. Dentists are now able to create objects using a board range of metals and metal alloys that can be used in prosthetic framework fabrication to produce

³⁴ Paulo Riberio, Accuracy of Implant Casts Generated with Conventional and Digital Impressions—An In Vitro Study, Published: 27 July 2018, 2.

³⁵ Ibid,3.

³⁶ A Dawood et al, "3D Printing in Dentistry." British Dental Journal 219, no. 11 (Dec, 2015a): 527.

high precision dental prosthesis for a patient.³⁷ Another advantage of 3D printing is in the ability to use multiple print heads to simultaneously print objects using different materials and thus making it possible to control the physical properties of the printed structure.³⁸ A structure could now be created to have both flexible and rigid parts which would provide a clinician with more options when selecting a material to use on a patient.

Times saving would be another cost saving benefit to the organisation. With the technology that is currently available it would be possible for a patient to receive treatment in a fraction of the time required in the past with the information stored in the patient's record. The technical schematics of a patient's dental appliance can be digitally stored in the patient's electronic health record and can be accessed anywhere around the world when required. A dentist could fabricate a replacement appliance in a matter of hours. The ability to fabricate appliances in an operational setting or in an isolated location would be revolutionary. An example of this can be seen in the way the organisation is able to treat snoring patients on a deployment. Developing technologies could provide the organisation with the capability to provide treatment at location and not be required to delay treatment until the member is repatriated. An appliance that could normally take weeks to fabricate could be made in a matter of hours. The quantity of supplies required and the room required to store these supplies is another factor the organisation would be required to take into consideration. The reduction of the quantity of supplies required in location and the storage foot print required to operate a 3D printer in the foreseeable future could be less in comparison to the current foot print required to

³⁷ A Dawood et al, "3D Printing in Dentistry." *British Dental Journal* 219, no. 11 (Dec, 2015a): 527.

³⁸ *Ibid*,526.

operate a clinic nowadays. 3D technology could help alleviate a wide variety of storage issues both in a clinical and in an operational environment.

Similarly the capability of a clinic would not be limited to the supplies it has available. If supplies are limited in an area or are not readily available due to logistics, the fabrication process could be farmed out to another clinic and an appliance could still be made available in a fraction of the conventional time. In an operational setting it would be expected that a supply chain back home would still be required but organisation will need to conduct a needs assessment to evaluate to what extent for each individual operation.

ORAL SURGERY

Oral Maxillofacial Surgeons have been early adopters of 3D technology for the past decade, and have passionately embraced the use of computer-aided design and manufacturing.³⁹ The clinical applications and advances in current 3D technology are enabling surgeons to rapidly capture 3D images and use these images to help with the diagnosing, treatment planning and treatment of surgical cases.⁴⁰ Radiographic examination is an indispensable part of the diagnosis and treatment planning for the majority of surgical cases today. The current use of 2D imaging comes with limitations when compared to 3D imaging technology. One must be aware of the unique inherent limitations of distortion, magnification, and superimposition on an image being produced when trying to take a 2D image of a 3D object.⁴¹ To be able to effectively treat patients a dentist requires a greater understanding of the proximity of vital structures from one

³⁹ A Dawood et al, "3D Printing in Dentistry." *British Dental Journal* 219, no. 11 (Dec, 2015a): 521.

⁴⁰ McNamara, C., L. Zhang, M. J. Clover, J. R. Sandy, K. Alemzadeh, K. House, A. J. Ireland, N. Wenger, and M. E. Barbour. "3D Surface Imaging in Dentistry - what we are Looking At." *Bdj* 205, no. 7 (Oct, 2008): 391.

⁴¹ Elluru Venkatesh et al, "*Cone Beam Computed Tomography: Basics and Applications in Dentistry.*" *Journal of Istanbul University Faculty of Dentistry* 51, no. 3 Suppl 1 (2017):106.

another and more so for oral maxillofacial surgeons. Most of the limitations from 2D imaging can be overcome with CBCT technology. CBCT has become an indispensable tool in the field of pathology and is used routinely for the evaluation of pathology. CBCT can provide 3D images of un-erupted and impacted teeth, help in the determination of location and extension of pathologies of the jaws and their association with vital structures.⁴² This technology affords the ability of an OMFS surgeon to medically model anatomical structures in 3D.⁴³ The images can also be used to evaluate bone graft receiver sites, osteonecrosis of the jaw, and assessments of patients with obstructive sleep apnea.⁴⁴ In some cases of severe facial trauma, a surgeon could use existing records to assist in the pre-planning stages for surgery which could greatly improve the accuracy of structures being replaced with the help of computer-aided design (CAD) software.⁴⁵ This technology would be beneficial in the fabrication of surgical guides and appliances and could greatly improve the outcome for the patient post-operatively.⁴⁶

Literature has supported the suggestion that 3D images taken by CBCT are far superior to conventional 2D images in the description of lesions and bony defects due to absence of superimposition of anatomical structures.⁴⁷ Breakthrough in these technologies allows for accurate measurements of bony defects and the assessment of a surgical site

⁴² Elluru Venkatesh et al, "*Cone Beam Computed Tomography: Basics and Applications in Dentistry.*" Journal of Istanbul University Faculty of Dentistry 51, no. 3 Suppl 1 (2017):107.

⁴³ Takashi Kamio et al, "Utilizing a Low-Cost Desktop 3D Printer to Develop a "one-Stop 3D Printing Lab" for Oral and Maxillofacial Surgery and Dentistry Fields." 3D Printing in Medicine 4, no. 1 (Dec, 2018): 4-5.

⁴⁴ Elluru Venkatesh et al, "*Cone Beam Computed Tomography: Basics and Applications in Dentistry.*" Journal of Istanbul University Faculty of Dentistry 51, no. 3 Suppl 1 (2017):109.

⁴⁵ A Dawood et al, "*3D Printing in Dentistry.*" British Dental Journal 219, no. 11 (Dec, 2015a): 521.

⁴⁶ Takashi Kamio et al, "Utilizing a Low-Cost Desktop 3D Printer to Develop a "one-Stop 3D Printing Lab" for Oral and Maxillofacial Surgery and Dentistry Fields." 3D Printing in Medicine 4, no. 1 (Dec, 2018): 4-5.

⁴⁷ Elluru Venkatesh et al, "*Cone Beam Computed Tomography: Basics and Applications in Dentistry.*" Journal of Istanbul University Faculty of Dentistry 51, no. 3 Suppl 1 (2017):114.

post operatively.⁴⁸ CBCT imaging allows for early detection of treatment failure when compared to limitations from 2D images.⁴⁹

The development of 3D technology has provided the surgeon with the ability to replicate sophisticated complex anatomical structures. An oral maxillofacial surgeon can now take information from a 3D scan and 3D print an anatomical prosthesis before a surgery. For the initial planning process, this will greatly help the surgeon to visualize the structure and the vital anatomy around the surgical site. The surgeon can also have a replacement prosthesis fabricated ahead of time which could provide greater control and increase accuracy during the day of the surgery. In addition to accuracy, surgical time could be reduced as the replacement prosthesis will be readily available ahead of time and the requirement to make adjustments could be greatly reduced. In isolated locations with limited access to resources, the ability to fabricate prosthesis when required could help reduce dependency to outside organisations and provide more treatment options to a patient in those locations.

As a diagnostic tool, a surgeon could be able to simulate the effects of surgery for a patient which would greatly help with the surgical planning of a case.⁵⁰ Some would argue that the use of computer-aided design (CAD) software as a surgical planning tool does have limitations. In a case requiring facial reconstruction, a surgical team could use 3D technology to map, mirror, and rapidly prototype the deformity to recreate a facial prosthesis.⁵¹ As part of informed consent, a patient must be made aware of possible

⁴⁸ Elluru Venkatesh et al, "Cone Beam Computed Tomography: Basics and Applications in Dentistry." *Journal of Istanbul University Faculty of Dentistry* 51, no. 3 Suppl 1 (2017):114.

⁴⁹ Ibid.

⁵⁰ McNamara, C., L. Zhang, M. J. Clover, J. R. Sandy, K. Alemzadeh, K. House, A. J. Ireland, N. Wenger, and M. E. Barbour. "3D Surface Imaging in Dentistry - what we are Looking At." *Bdj* 205, no. 7 (Oct, 2008): 391.

⁵¹ Ibid.

limitations of any technology as a prediction tool and similarly should be made to understand that the technology helps predicts the likely effects of a surgery and not the final outcome.⁵² An argument can be made that it is more of a challenge of predicting the healing of soft and underlining tissue after any surgical procedure then from the technology itself.⁵³

As 3D printing of structures becomes the norm in the dental practice, the organization must look into finding cost effective ways to reduce the cost of treating patients. Some would argue that an extremely inexpensive desktop fused deposition modeling (FDM) 3D printer could be a viable option in the future for a 3D printing lab in a dental clinic.⁵⁴ It is predicted that use of 3D technology in the field of oral and maxillofacial surgery will likely increase. But as the use of 3D technology becomes the standard of care in the treatment of patients, the organisation will need to strategically plan for the future to predict what role this technology could play in the organisation.⁵⁵

COUNTER ARGUMENT

Even though 3D technology is being rapidly adopted in the field of medicine and dentistry, it is not deprived of drawbacks. This can be said with regards to Cone Beam Computed Tomography (CBCT), Intraoral Scanners (IOS) and three-dimensional dental printing technology.

Major drawbacks with Cone Beam Computed Tomography (CBCT) units are that the clarity of images can be affected by multiple issues not to mention radiation exposure to a

⁵² McNamara, C., L. Zhang, M. J. Clover, J. R. Sandy, K. Alemzadeh, K. House, A. J. Ireland, N. Wenger, and M. E. Barbour. "3D Surface Imaging in Dentistry - what we are Looking At." *Bdj* 205, no. 7 (Oct, 2008): 391.

⁵³ *Ibid.*

⁵⁴ Takashi Kamio et al, "Utilizing a Low-Cost Desktop 3D Printer to Develop a "one-Stop 3D Printing Lab" for Oral and Maxillofacial Surgery and Dentistry Fields." *3D Printing in Medicine* 4, no. 1 (Dec, 2018): 2.

⁵⁵ *Ibid.*,1.

patient. Limiting the amount of radiation that a patient is exposed too must be taken into consideration when deciding to implement CBCT technology as a tool to be used during an initial examination. A patient obtaining a CBCT scan receives an equivalent dose of 5 to 74 times that of a panoramic radiograph.⁵⁶ The organisation must hold true to the concept of the requirement of “the need to know” verse “the want to know” before deciding to exposing a patient to a radiograph.

In addition, Cone Beam Computed Tomography (CBCT) images can be effected by artifacts such as patient related artifacts, beam hardening, cone beam related artifacts and scanner related artifacts which can lead to poor image quality and limit visualization of anatomical structures in the region.⁵⁷ A major drawback in Cone Beam Computed Tomography (CBCT) is “Metal Artifact” which greatly affects the quality of the image produced and a challenge to overcome in some cases.⁵⁸The implementation of this technology must include consultation with both patients and the health care profession to ensure that all parties involved have a full understand the pros and cons of CBCT over current technology in the clinics.

Given the emergent importance of 3D printing, this technology too comes with major drawbacks along with significant health and safety challenges post-processing. Particle waste management will need to be addressed in the clinics before this technology can be introduced in any organisational environment.⁵⁹In a small dental clinic where small numbers of units are required, this technology may not be cost effective in comparison to

⁵⁶ Elluru Venkatesh et al, "*Cone Beam Computed Tomography: Basics and Applications in Dentistry.*" Journal of Istanbul University Faculty of Dentistry 51, no. 3 Suppl 1 (2017):105.

⁵⁷ Ibid,106.

⁵⁸ Park, W. S., K. D. Kim, H. K. Shin, and S. H. Lee. "Reduction of Metal Artifact in Three-Dimensional Computed Tomography (3D CT) with Dental Impression Materials."IEEE, Aug 2007. doi:10.1109/IEMBS.2007.4353084. <https://ieeexplore.ieee.org/document/4353084>, 3496.

⁵⁹ A Dawood et al, "*3D Printing in Dentistry.*" British Dental Journal 219, no. 11 (Dec, 2015a): 527.

traditional casting procedures.⁶⁰ Although literature supports a one machine operation in a dental clinic, in practice it is extremely difficult and not practical to maintain such a practice.⁶¹ The requirement in having to switch between different materials in a one machine operation in order to fabricate different appliances and frameworks may not be practical in the treatment of patients in a small clinic.⁶²

As with all new technology being introduced into an institution, an understanding of the complete up-front cost to procure this technology along with the effect it will have on the Human Resource Management (HRM) in an organisation must be defined. There will be a requirement to upgrade the organisations infrastructure in order to accommodate the introduction of this new technology. This to include more powerful computers to run these imaging programs, increase computer band width and storage space for these images along with an understanding of the requirement of maintain this equipment.

Furthermore, the organisation must accept the possibility that even this technology will become obsolete in a few years' time and the requirement to build into the procurement process a shorter life cycling date on equipment. The organisation could consider the option of leasing this technology verse purchasing outright. A short-term lease could provide the organisation with the flexibility to replace equipment that becomes outdated due to future advancements in technology.

HRM will also play a critical role in the ability to implement this technology into the organisation and will be a large factor in the overall cost. When one looks at resourcing, HRM will be required to supply a workforce that is capable of using this technology in

⁶⁰ A Dawood et al, "3D Printing in Dentistry." *British Dental Journal* 219, no. 11 (Dec, 2015a): 527.

⁶¹ *Ibid.*

⁶² *Ibid.*

the organisation. In the current institutional construct, HRM will be responsible to provide and manage a mixture of public servants, military and 3rd party contractors capable of using this technology along with the acquisition of skills and knowledge for current employees. The development of this new skill set in current employees could present a challenge for HRM in the organisation along with the ability to recruit employees with this highly specialised skill set. The investment in the training of current employees will need to be factored in any business plan that will be developed for the organization.

An understanding that digital may not always be better, leads to the recommendation that the organisation must avoid jumping in “head first” into this technology without fully understanding the complete cost to the institution. A requirement to define a standard in the work place and confirm that the recommended treatment modality will perform as well as current conventional “analogue” processes should occur before the organisation decides to procure this technology.⁶³

CONCLUSION

Few would argue today that 3D technology is here to stay, but the question that is on the minds of many in the organisation is on how this technology will alter the way the Royal Canadian Dental Core (RCDC) will practice in the foreseeable future. Given the emergent importance of resource management, the organisation requirement to balance costs against efficiency when introducing any new technology in a group practice as large as the Royal Canadian Dental Core (RCDC) is more than ever becoming a factor in the decision making process. The requirement to be fiscally responsible in the procurement

⁶³ A Dawood et al, "3D Printing in Dentistry." *British Dental Journal* 219, no. 11 (Dec, 2015a): 528.

of any new technology comes with the challenge of evaluating what the true value this technology would bring to the organization. Strategic planning at the organisational level is gaining increasing importance in both the procurement level and at the HRM level and the requirement to fully understand the cost effective impact to the institution.

As the CAF starts to lifecycle out older technology and non-functional equipment, Royal Canadian Dental Core (RCDC) will need to decide if the organisation wishes to embrace this new technology at this point in time. It is the views of this author that the practical application of these technologies in the field of Forensics, Operative Dentistry, and Oral Surgery has been proven in the literature to show great promise as a tool in the treatment of patients and could easily be adapted in the organisation.

A challenge for the establishment will be in the ability to recruit health care providers trained in using this technology along with the challenge in providing training to current health care providers in the organisation. The dental community is quickly becoming one of the leading healthcare institutions in adopting this technology and it would be advantageous for the organization to work jointly with other organisations in the CAF to develop this technology.

It is expected that organisational legitimacy will play an important role in any requirement for an institution to obtain a technology. As a technology becomes the standard of care in the dental community, the legitimacy of how an organization decides to stay ahead of emerging technology may come into question from members inside the and institution who may perceive a difference in the level of care being delivered in comparison to others in the community. The opportunity this technology presents to the organisation is considerable as long as the institution is able to look past 3D technology as just being a replacement tool but as a technology that will allow the organisation to be

more creative, cost effective and improve the quality of life for the members in the organisation.

Even though the benefits of having access to this technology would be of tremendous value from a patient treatment perspective, the challenge for the organization will be in its ability to leverage this technology for the benefit of the people in the organisation and thus set up the institution for long term success.

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