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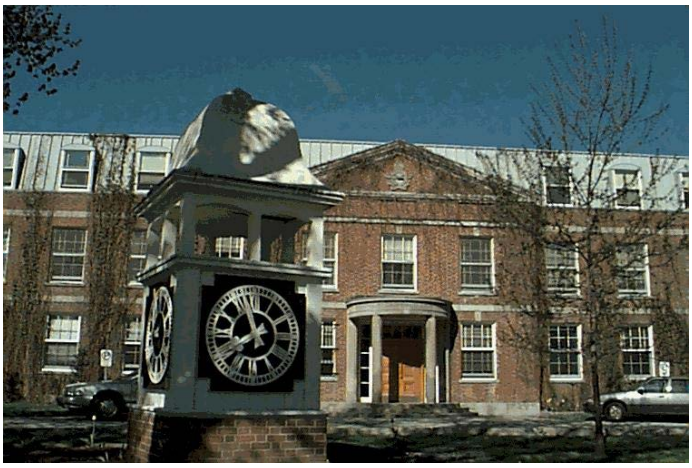

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3D SCANNING AND PRINTING: THE FUTURE OF DENTISTRY IN THE MILITARY

By Major Domenico Belcastro

AIM

1. The introduction and implementation of any new dental technology in the Canadian Armed Forces (CAF) has always been a slow process when compared to the implementation process of our civilian counterparts. This holds true to 3D scanning and printing technology (3D S&PT) to date. With the new advances in 3D S&PT that is occurring in the civilian sector, the discussion to the value of implementing this technology in the CAF has become a relatively new endeavour along with other competing procurement projects that are currently on the table at this time. As dated equipment starts to become life cycled out of the dental detachments, the procurement priorities will need to be re-evaluated to address this new technology. Coined a 'Disruptive Technology'[1], 3D S&PT is evolving to a degree such that the way we practice dentistry today may not be the way we will be practice dentistry down the road in 5 years' time. This paper will examine the advantages of 3D scanning and printing technology in dentistry and the positive and negative affects it could have on the management of the supply chain for 1 Dental Unit Detachments in the CAF.

INTRODUCTION

2. 1 Dental Unit Detachments in the CAF has been compared by the organisation as a large group practice with the basic principle that new technology and equipment are only introduced to the organization once the technology has been tested and deemed safe. At times, the procurement of new equipment will only be entertained by the organisation when outdated equipment requires to be life cycled out of the system. This may be frustrating to some providers in the organization as various advances may have additional benefits to the way patients could be treated. The unit tries to maintain a happy balance between providing the best equipment for patient treatment and adopting new technology when appropriate. Leadership at 1 Dental Unit has always been reserved when implementing new technology as there will always be a want, in any organization, to have the latest and greatest piece of equipment which at times can come at a huge price to the tax payer. Unlike our civilian counter parts where costs of implementing new technology in a practice can be transferred to the patient directly, this method would not be possible in our organization and therefore the CAF has an obligation to be fiscally responsible in the procurement of any new technology. Understanding the current needs of the organization and the future needs involves long term strategic planning before any large procurement can be made. Past implementation of 2D digital radiographs and digital patient charts are examples of successfully implementation of so called 'Disruptive Technologies'[2] in Health Services and 1 Dental Unit Detachments. Although twelve years later, there is discussion to replace this technology due to new advances in the field, one cannot be but impressed by the longevity and effectiveness of this technology in the organisation.

3. The in garrison and in theater requirements essential to provide patient treatment will be reviewed and discussed along with the advantages of the application of 3D scanning and printing technology in the field of Forensics, Operative Dentistry, and Oral Surgery. This paper will also review the positive and negative consequences to procure this new technology and the affects

[1] (Dawood and others 2015, page 521)
[2] (Dawood and others 2015, page 521)

this technology could have on the supply chain and supply management for 1 Dental Unit Detachments in the CAF.

DISCUSSION

4. The expression "3D printing" is generally used to describe the process of rapid prototyping of an object were the object is formed by adding layers on top of each other one at a time.[3] This is a technology that will change the face of medicine and dentistry as we see it today. For the past few years the aerospace community at large has been leading the charge in the development of a practical use for 3D printers and recently the medical and dental community have started to see the value in similarly embracing this technology. 3D printers are apparatus that incorporate 3D scans with the aid of computer-aided design (CAD) software allowing the end user to use this information to develop and design objects in a virtual environment.[4] It has only been recently that the average civilian Dental and Oral and Maxillofacial Surgery (OMFS) practice have the ability to access cone beam computed tomography (CBCT) scans and computed tomography (CT) scans for patient treatment. These practices are now able to use this technology to treatment plan cases in 3D with the aid of dental specific computer-aided design (CAD) software.[5] As this technology starts to become the standard of care in treatment planning, the transition from 2D imaging to that of 3D imaging will need to be addressed as the CAF starts to life cycle out dated equipment from the detachments.

5. This new technology will have many practical applications in the treatment of patients. Starting from day one, all new recruits that enter the CAF require an initial forensic dental examination by a dentist which could take up 30 minutes to perform. During this appointment the dentist collects metrics on the patient dentition. This is very time consuming and does require resources to perform. The dentist records a 3D view of the patient's dentition into a 2D chart format. In this situation, 3D technology could be used to quickly and more accurately chart a patient's dentition by taking a 3D digital scan of the dentition along with a 3D radiographic scan and digitally storing the information in an electronic format.[6] From start to finish, this could take 10 minutes of clinic time and provide a forensic record of the patient that is far superior to that of the 2D method of charting currently being used. The information can be then stored in an electronic format to assist the dental provider with patient treatment when required. There has been discussion to explore the feasibility of storing digital medical information on a digital ID card for a patient own personal records. The storing of 3D information could be used with the same technology. The initial up-front cost would be higher than the traditional 2D technology but 3D digital scanning and printing technology along with the CBCT seems to be the direction that the medical and dental profession is heading towards and may be a matter of time before this technology becomes the standard of care.

6. The application of this technology for providing treatment to CAF members similarly looks promising. It could be feasible for a patient requiring dental treatment to have a restoration replaced or repaired in a fraction of the time that it would normal take with the use of the 3D

[3] (Dawood and others 2015, 521-529)
[4] (Dawood and others 2015, 521-529)
[5] (Kamio and others 2018, 4-5)
[6] (Rajshekar and others 2017, 202-203)

information that has been previously stored in the patient record. With a specifically designed 3D printer, the dentist could even fabricate a replacement tooth or appliance that same day. [7] One would be able to have the technical schematics of a patient's dental appliance stored digitally in the patient's dental record and be able to access the information at any time. The application of this technology would likewise be revolutionary in theater. A new snoring appliance could be fabricated for a patient that requires one on short notice or a replacement for a broken appliance can be fabricated on the spot.[8] The ability to fabricate appliances in location would be ground breaking as at present this is not possible in a timely fashion. In addition to the time savings, the foot print on ground and the supplies required to operate a 3D printer would be less in comparison to having to support a fully functional clinic in theater. If deemed not practical or cost effective to have this technology available in theater due to the mission logistics, the dentist could electronically send the 3D scan of the patient appliance to any lab in the world to have the appliance fabricated and return to the dentist in half the conventual time required. A supply chain back home would still need to be maintained but not to the same degree or level.

7. One of the greats promises seen in this technology would be in the application in the OMFS field. With this technology, OMFS surgeons would have the ability to medically model anatomical structures in 3D.[9] An OMFS surgeon could effectively treat a patient presenting with severe facial trauma with the aid of the CBCT scans stored on the patient's ID digital disk or on record. The surgical team could use a 3D printer along with the volumetric date from the CBCT scan to fabricate exact replicas of the patient's jaws or missing structures.[10] 3D printers can be used to fabricate surgical guides for implant treatment and for orthognathic cases. This technology would be beneficial in the pre-planning stages for surgery and would greatly improve the accuracy of structures being replaced.[11] The flexibility of using the technology during the time of surgery is also revolutionary. It would be possible for a surgeon to take a 3D image during surgery and refabricate a new guide if required. The ability for a surgical team to have access to this information before and during a surgery could significantly improve the aesthetic outcome that can be achieved and substantially improve the quality of life the patient may expect to have post-surgery.

8. Another application that would be well suited for this technology would be in the field of forensics.[12] Currently when asked by the organisation to help identify a person, a dentist would review 2D information and attempt to make a match to the dentition that is presented. As one would expect, there is some limitations to trying to overlay 2D information onto 3D information. More data that the dentist can access would increase their ability to positively identify a member in a timely fashion. Similar to the above situations, the initial cost would be high when precuring this type of equipment but would require less resources after to apply the information available in the system.

[7] (Hu Chen and others 2015, page 5)
[8] (Hu Chen and others 2015, page 5)
[9] (Kamio and others 2018, 4-5)
[10] (Dawood and others 2015, 521-529)
[11] (Kamio and others 2018, 4-5)
[12] (Rajshekar and others 2017, page 201)

9. The ability to 3D print restorations, stents, guides, and appliances would have a positive effect in the dental supply chain management. The capability to print supplies would benefit patient treatment immensely. The CAF would not be dependent on an outside organizations timelines to obtain supplies and would not be limited to working with single source organization to the same extent. The initial up-front cost would be offset by the savings of being able to fabricate what the patient requires inhouse. This technology could be a partial answer to reducing the costs of medical and dental supplies that we incur from the civilian sector.

10. As with all new technology, there will be an expected higher up-front cost to be able to transition 1 Dental Unit detachments to this new technology. Nevertheless, as 1 Dental Unit begins to life cycle out its dated equipment, this may be an opportunity to build in these new capabilities into the procurement plan and thus set up the organisation for long term success in the future. Furthermore, one must understand that 3D technology, like all other technology, will become outdate over time with the development of new software and the improvement in computer technology. The consideration to leasing this technology for a set period of time verse purchasing outright may be a more prudent course of action to explore as there may not be any value in owning the equipment in 5 years' time. A short-term lease would provide the mechanism required for the organization to replace outdated technology in a timely fashion.

11. As the medical and dental community becomes one of the leading institutions in employing this technology, if would be advantageous for the organization to be able to work jointly with other members in the CAF when implementing 3D scanning and printing. The sharing of human and material resources would be beneficial form both a cost and times savings point of view. The organisation could explore the feasibility of standardizing equipment and resources as another cost saving measure. It is within the realms of this technology that a non-critical part that may cost the organisation thousands of dollars to obtain by conventual means could be fabricate by a medical/dental 3D printer for pennies. Exploring what others could bring to the table and working jointly with other CAF members in developing our own CAF SMEs will be what sets us apart from other militaries and civilian organizations.

CONCLUSION

12. It is predicted that 3D scanning and printing technology will significantly alter the way the CAF conducts business for the foreseeable future. As the CAF starts to lifecycle out dated equipment, 1 Dental Unit should plan for the future and be prepared to embrace this new technology before our outdated technology makes us irrelevant. 3D S&PT is expected to revolutionize the practice of dentistry and will greatly change the way we treat patients in garrison and in theater. The practical application of 3D printing currently being demonstrated in Forensics, Operative Dentistry, and Oral Surgery shows great promise in our ability to apply the same technology in the CAF environment. As with all new technology introduced into a group practice, there will be some resistance in adopting and applying this technology, but the potential positive effects on the supply management system for 1 Dental Unit Detachments and in the CAF in general could be enormous. How Health Services and 1 Dental Unit will approach the integration of 3D scanning and printing technology alongside the next generation of 3D digital radiographs and digital patient charts will be the next big challenge that, if successfully implement, could make the organization a model to follow. The future for 1 Dental Unit and the

CAF will be in determining how best to leverage this technology to be able to help the organization work more efficiently for the benefit of its members.

RECOMMENDATIONS

13. The understanding of the practical application of this technology would be a fundamental requirement for the CAF to develop. The CAF would need to invest in a core of early adaptors to lead the push to develop this technology. This core of early adaptors should be a blend of military, public servants and 3rd party contractors. This group of early adaptors would also require the support and resources from the chain of command if the organisation wishes to adapt this technology sooner than later. The Army, Air Force and Navy would benefit from working together and pooling resources to avoid working in silos. The value to the organisation in jointly developing SMEs in this technology would be both in time savings and in costs saving. Doctrine would likewise need to be developed to address the life cycling of this technology along with the formation of a committee to look at the future needs of the organization with regards to procurement of this technology. Lastly, when a technology is deemed to be a 'Disruptive Technology', the organization should rapidly develop a committee to evaluate the technology in question and determine how best to apply that technology.

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