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A Comparison of Conventionally Versus Digitally Fabricated Denture Outcomes in a University Dental Clinic

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Abstract

Purpose: The purpose of this retrospective, cross-sectional study is to evaluate if there is a difference in number of visits (including fabrication and postoperative) and remake rate when comparing conventionally fabricated and digitally fabricated complete dentures by dental students in a predoctoral student dental clinic.

Materials and methods: This two-year retrospective cross-sectional study consisted of a chart review for patients receiving maxillary and/or mandibular complete dentures between 2017 and 2019 (n = 314) at the UNC Adams School of Dentistry predoctoral student clinic. No control group was determined for this study. Data were extracted for 242 conventional dentures and 39 digital dentures. Objective treatment outcomes were obtained for each included denture: the number of patient appointments from preliminary impressions to denture placement, the number of postoperative visits, any complications noted, and any need for remakes. Fisher's Exact Test and Cochran-Mantel-Haenszel analysis were completed with statistical significance set at $p < 0.05$.

Results: For the number of visits from preliminary impression to placement, 50% of conventionally fabricated dentures had 6 or more visits, while only 5% of digitally fabricated dentures had 6 or more visits. This difference for the number of patient visits was statistically significant ($p < 0.05$). Additionally, conventionally fabricated dentures required an average of 2-3 postoperative visits, whereas digitally fabricated dentures required 1-2 postoperative visits. This difference was also statistically significant ($p < 0.05$). For the number of dentures requiring remake, there was no statistical difference ($p = 0.1904$).

Conclusions: When comparing conventionally fabricated and digitally fabricated dentures in the predoctoral clinic, the digitally fabricated dentures required fewer patient appointments from start to finish, and fewer postoperative appointments than conventionally fabricated dentures. Fewer visits may be an important consideration for patients, especially those with limited access to care.

In recent years, digital technology and CAD/CAM workflows have changed the way clinicians practice nearly every aspect of dentistry. This evolution is also evident in the dental school curriculum, as technology is being incorporated into more areas.[1] There is an acknowledged responsibility and desire for dental school training to introduce clinicians to newer technologies.[2] One of the newer areas that dental schools are introducing technology is digitally fabricated dentures, both clinically and didactically.[1,3]

While the earliest reference in the literature of CAD/CAM complete denture fabrication was as early as 1994,[4] this modality was not considered a viable clinical concept until 2012 when Goodacre et al published what is considered the "proof of concept" article.[5] This same year, there were only two commercially available digital denture companies (Dentca, CA and Avadent, AZ), and only a few available digital workflows.[6] This has changed over the past 5 years, as digital technology in removable prosthodontics has become much more prevalent. Less than a decade later, digitally fabricated dentures are produced through many companies and dental laboratories, and there are numerous workflows available.[7–10] While there are many options available, the definitive digitally fabricated complete denture prosthesis can be defined as one of two fabrication methods: three-dimensional

(3D) printing (additive manufacturing), or milling (subtractive manufacturing).

Before introducing a new product or technique on a large scale in a clinical environment, it is important to establish equivalence (or superiority). It should be noted that milled complete dentures have been in use since 2012 in the United States, while 3D printed materials did not gain initial FDA clearance for intraoral use until late 2015. Consequently, there is a more extensive literature base available for milled complete dentures as compared to 3D printed complete dentures. Although the technology is relatively new, there is growing evidence that the clinical outcomes of digitally fabricated dentures trend toward favorable - particularly for milled dentures.[11–15] Digitally fabricated dentures generated by milling are typically milled from a puck of poly(methylmethacrylate) (PMMA). This is the same material as a conventionally fabricated denture, but it is a prepolymerized resin puck that can be subsequently milled. A resulting benefit of milled PMMA is that it can be relined and repaired the same as conventionally processed PMMA dentures, and has equivalent biocompatibility.[16] Additionally, studies are beginning to emerge that demonstrate improved material properties for digitally fabricated dentures when compared to conventional processing. With conventional denture fabrication, "processing error" is inherent in the material, requiring accommodation to achieve an ideal fit. This has been studied with milled dentures showing as good[17] or improved[18–22] fit/retention than conventional processing (press pack, pour and injection methods). Other studies have shown dentures fabricated by milling have improved tensile strength and fracture toughness.[12,16] These properties are further improved with a monolithic puck, where the teeth and denture base are milled out of the same material, from a single puck (Avadent, AZ; Ivoclar, NY). There is no longer a weakening of the tooth or denture base as it is thinned out to accommodate reduced space, and the material itself is stronger. The surface of a digital denture (fabricated by milling) also exhibits less surface roughness than conventional processing,[16] which can lead to less bacterial adhesion and improved tissue health.[23]

There are also a few studies that evaluate patient satisfaction. Particularly, a survey of patients who received digitally fabricated dentures found that the patients were generally pleased with their complete denture prostheses, and reported improvement compared to their previous conventionally fabricated denture experience.[13] A commonly reported reason for satisfaction is decreased treatment time. There is an average of 5 visits for a conventional workflow, and 2-3 for digital workflow to fabricate a complete denture. Fewer visits can translate to less chair time for the clinician, and less burden to travel to appointments for a patient. Ultimately, this can result in reduced expenses for the clinician and patient.[14,24–25]

Since few predoctoral dental programs have adopted digitally fabricated dentures, there is a lack of evidence on how these clinical benefits translate to dental student providers. The purpose of this retrospective study is to determine if there is a difference in the number of visits (both for fabrication and postoperative) and remake rate when comparing conventionally fabricated and digitally fabricated complete dentures by dental students in the predoctoral student clinic setting at the University of North Carolina at Chapel Hill (UNC-CH).

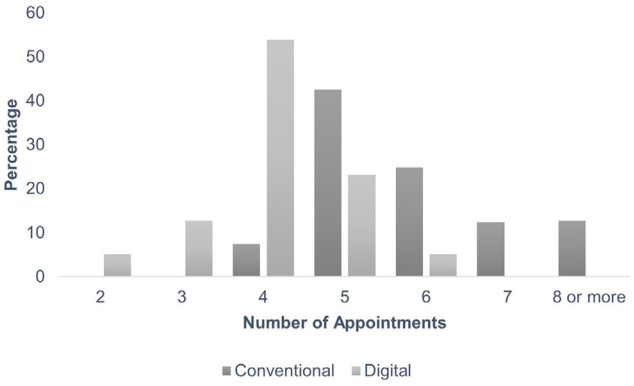

Figure 1 Number of appointments from start (preliminary impression) to finish (placement), for conventionally and digitally fabricated dentures.

Materials and methods

This investigation consisted of a two-year retrospective chart review of complete denture patients at the UNC-CH Adams School of Dentistry predoctoral student clinic (IRB# 19–0888). Data were extracted via the electronic health record for patients receiving either conventionally or digitally fabricated maxillary and/or mandibular complete dentures between 2017 and 2019 (n = 314). Charts were excluded (n = 33) from the study if there was lack of documentation for any of the clinical appointments, or if the patient did not receive a complete denture prosthesis for any reason. This documentation included five steps for conventionally fabricated dentures (1. Preliminary impressions, 2. Definitive impressions, 3. Maxillomandibular relations, 4. Clinical (wax tooth) try-in, 5. Placement) and four steps for digital dentures (1. Preliminary impressions 2. Definitive Impressions, 3. Wagner Try-in, 4. Placement). After exclusion, data were extracted for 242 conventional dentures and 39 digital dentures.

Three individuals (BB, DM, and JS) gathered the data for this investigation after developing a template to standardize data collection. Objective treatment outcomes were obtained for each included complete denture prosthesis: the number of patient appointments from preliminary impressions to placement, the number of postoperative visits, any recorded complications, and any need for remake. After data collection, each reviewer was assigned to review the data of another individual to minimize variability.

Data were imported into analytical software (SAS), and a bivariate analysis was completed. Fisher's Exact Test and Cochran-Mantel-Haenszel analysis were completed. Statistical significance was set at $p < 0.05$.

Results

For the number of visits from preliminary impression to placement, 50% of conventionally fabricated complete dentures required 6 or more visits, compared to only 5% of digitally fabricated complete dentures (Fig 1). It was not unusual for the conventionally fabricated complete dentures to require 8 or more appointments in this predoctoral dental school setting. Based on Cochran-Mantel-Haenszel, there was a statistically

Figure 2 Number of postoperative appointments for conventionally and digitally fabricated dentures.

significant difference for the number of patient visits for digitally versus conventionally fabricated complete denture prostheses ($p < 0.0001$).

The number of postoperative visits also varied between digitally and conventionally fabricated complete dentures. On average, patients receiving conventionally fabricated complete dentures required 2-3 postoperative visits, compared to 1-2 postoperative visits for digitally fabricated dentures (Fig 2). For digitally fabricated complete dentures, none of the patients returned for more than three postoperative visits, while some patients with conventionally fabricated complete dentures returned 5 or more times. Based on Cochran-Mantel-Haenszel, there was a statistically significant difference for the number of postoperative visits for digitally versus conventionally fabricated complete dentures ($p = 0.0298$).

For denture remakes, there was no statistical difference ($p = 0.1904$). However, of the 281 complete dentures analyzed, 33 were determined necessary to be remade. Of these, 28 were conventionally fabricated.

Discussion

The greatest limitations of this study were the population size, the discrepancy in the number of participants between groups, the lack of control groups, and the length of time over which the charts were reviewed. Due to the novelty of this workflow, it has been introduced into few predoctoral dental programs and was not implemented in our school until the last few years. As such, the population of the digitally fabricated group was much smaller than the conventionally fabricated group, and the follow-up was short for both groups. Ideally, there would be a larger and more even sample size for each group, and the follow up would be longer to see if there are any differences in long term remakes/complications. Over time, it would be interesting to follow up and see if these trends change in any way.

There was a statistically significant decrease in the number of appointments for both the total number of visits and the postoperative visits. The average number of appointments for the digitally fabricated complete dentures in this study is higher than the average number for this workflow in general. When the implementation of a digital denture workflow was discussed at the UNC-CH clinics, it was decided to add one appointment to the standard three visit digital denture workflow. Many methods offer the advantage of taking the final impression at the first appointment. To allow the dental students additional practice making preliminary alginate impressions as well as fabricating custom impression trays, an extra appointment was added to the digital workflow. With this in mind, our results are consistent with the outcomes from other pre- and postdoctoral dental programs.[13,15] Additionally, the findings align with manufacturer and laboratory claims regarding a decreased number of appointments for digital dentures when compared to conventional denture workflows.[6,7] It can be inferred that decreasing the number of appointments decreases the amount of chair time needed for complete denture fabrication in clinical practice. This not only improves the patient experience, but also the financial return.[26] There have not been many studies evaluating the potential financial benefits of digital dentures. Srinivasan et al completed a very thorough cost analysis, concluding that the financial gain from the decrease in chair time far outweighs any increase in laboratory cost.[25]

The conventional denture workflow requires an average of 5 visits, with 1-3 postoperative appointments.[26] Notably, UNC-CH dental students are required to conduct 3 postoperative visits; however, many of the patients receiving digital dentures only returned for one or two postoperative visits. Some of the patients declined to return for any adjustments. Without the student's clinical requirements of preliminary impression and three postoperative visits, perhaps the difference in the number of visits would be greater. A decrease in the number of appointments is perhaps even more consequential when taking into consideration the typical patient population in need of complete denture prostheses. Often, these edentulous patients are medically compromised, or have transportation or financial limitations. It may be more difficult for them to attend 5 or more visits. Digital denture workflows could significantly improve access to care concerns for edentulous patients and is worth further investigation.

One of the benefits (and complexities) of digitally fabricated dentures is the versatility of the workflow, and the number of possible techniques. In the predoctoral setting, predictability and consistency was an important factor in determining which workflow to implement. After a pilot study, the Wagner Try-in workflow from Avadent was chosen as the easiest transition for clinical faculty and staff. This workflow maintains the capacity to move the anterior denture teeth in wax and to record centric relation and vertical dimension of occlusion with a wax rim. As these are clinically similar to the standard steps of traditional steps in the fabrication of conventional complete dentures. For the definitive digitally fabricated complete denture prosthesis, monolithic milled PMMA was selected due its evidence base.

The last outcome that was evaluated with this study was the number of remakes. While there was no statistical significance in the number of remakes between digitally and conventionally fabricated dentures, there was a slightly higher remake rate with the conventionally fabricated dentures. The reason for remake was not always clearly documented, so was not

evaluated in depth as part of this study. Reasons for remake varied widely; for conventionally processed dentures, a lack of retention, underextension, and incorrect occlusion and/or vertical dimension of occlusion was noted for some of the cases. For digitally fabricated dentures, documented reasons for remake included requests to change the shade of the denture teeth and/or base.

While not explored, these more commonly noted causes of remake are likely a result of the workflows. Regarding the conventional workflow, a light cured resin record base was most often used to transfer the wax rim and clinical try-in. This differs from the digital workflow, where lack of retention/extension are evaluated in the digital try-in and can be corrected before placement. Additionally, the milled PMMA lacks processing error, resulting in improved fit.[15,19–22,24] For the digital denture cohort, the Wagner workflow precludes the try-in of the actual denture teeth. The shade of the milled complete denture sometimes varies slightly from the printed try-in. While not explored in this study, this could play a role in the need for esthetic remakes. One must consider, though, that regardless of the rate of remakes, the design of digitally fabricated dentures is archived. As a result, a remake could feasibly be made with fewer visits by capitalizing on the retrievability of the original design files.

Conclusions

When comparing conventionally processed and digitally fabricated complete dentures in predoctoral clinic, the digitally fabricated dentures required fewer patient appointments from start to finish, and fewer postoperative appointments than conventionally fabricated dentures. Fewer visits may be an important consideration for patients with limited access to care.

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