Clinical performance of CAD/CAM fabricated complete dentures: A retrospective study and assessment of patient satisfaction

Master’s Thesis

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By

Paola C. Saponaro Parra, DDS

Graduate Program in Dentistry
The Ohio State University 2015

Thesis Committee:
Burak Yilmaz, DDS, PhD, Advisor
Edwin McGlumphy, DDS, MS
Reza Heshmati, DDS, MPH, MS
Hua-Hong Chien, DDS, PhD
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ABSTRACT

Conventional methods of complete denture (CD) fabrication involve multiple and complex clinical and laboratory procedures. With the introduction of CAD/CAM fabricated CDs, these techniques seek to ameliorate the potential disadvantages associated with conventional complete denture fabrication and highlight potential advantages such as reduced number of patient visits and improved fit of the prostheses. However, comprehensive clinical data on CAD/CAM complete dentures, that conform to an evidence based approach, are severely lacking in the available literature. To date, there are few, if any, randomized clinical trials or retrospective analyses evaluating the clinical performance and behavior of CAD/CAM fabricated dentures. In this study, patients who received CAD/CAM fabricated CDs (AvaDent® Global Dental Science LLC, Scottsdale, Ariz.) at The Ohio State University College of Dentistry were identified. Using a dental software search tool (Windent EE; Carestream Dental), the total number of CAD/CAM fabricated CDs treated within the Pre-doctoral Comprehensive Care Clinics, Advanced Prosthodontics Clinic and Dental Faculty Practice Clinic between the years 2012 and 2014 were identified. Retrospectively, data were collected from these charts of patients. Data were collected from the reviewed charts to identify and assess objective and subjective treatment outcomes including: number of appointments needed to deliver the final complete denture prostheses, number of post delivery adjustments needed due to presence of sore spots, and the
reported complications with these prostheses such as compromised denture retention, fractures, incorrect vertical dimension of occlusion and/or incorrect centric relation. It was also determined whether the experience level of the operator had an influence on the number of appointments needed to deliver the final prosthesis and in the total amount of complications observed. In addition, a 13-item questionnaire was sent in the mail to those patients included in this study, in order to determine overall patient satisfaction with questions referencing their current complete denture experience. A total of fifty patients were included in this study (25 female and 25 male) between the ages of 26-90 with a mean of 62.64 years of age. The mean number of appointments needed to deliver the prosthesis in all operator experience categories (PRED, GRPR, DFP) was 2.38 compared to the control number of appointments claimed by the company as 2. In regard to post insertion adjustment visits, the mean number for the fifty patients treated was 2.12. Of the 94 arches completed, 23 prosthesis could not be delivered at the second appointment. For this, the most common reported reason were lack of retention (9/23) and incorrect vertical dimension of occlusion (4/23). All 23 dentures not delivered in the second appointment were delivered at the third appointment. No significant differences were found for number of appointments needed to deliver the prostheses in relation to operator experience. No differences were found for occurrence of a complication versus the level of operator experience. In regard to the survey component of this study, out of the 19 patients who participated, 14 of those were experienced denture wearers and it was concluded that this group, a significant difference could not be demonstrated in their ratings of agreement regarding the digital complete dentures being better than their conventional set. This data could suggest, as
the company claims, that this is a cost-effective treatment modality and proves beneficial for both the clinician and patient as the number of appointments needed to deliver these dentures was considerably less than those fabricated the conventional way, thus potentially enhancing productivity. This outcome, in turn, could translate into reduced chair time and cost burden to the clinician without compromising the quality of the overall treatment.
DEDICATION

This is dedicated to my family and friends for their unconditional love and support during this journey of becoming a prosthodontist. To my mother, Lisbeth, who has always made me believe that the sky is the limit and that life should be lived following your passions and seeking true happiness. Dedicated to my father, Sergio, may you keep protecting and guiding my footsteps from the heavens and know that every achievement in my life was done in your honor. I love you both.
Acknowledgements

I would like to infinitely thank my committee members for their guidance, patience, support, and inspiration during this process. I would like to thank my advisor, Dr. Burak Yilmaz for his positive attitude and continuous encouragement during all the phases involved in my study. I would like to thank Dr. Edwin McGlumphy for his incessant motivation during my residency and also for being one of the most influential people in my career as a young prosthodontist. I thank Dr. Reza Heshmati for always pushing me to “think outside the box” and to appreciate the simplicity of common prosthodontic procedures and not to stress out so much. I would also like to thank Dr. William Johnston for his kind help in agreeing to perform the statistical analyses of my data. I want to also thank Dr. Hua-Hong Chien for his support since my first year of residency when I decided to move forward with my study. Lastly, I would like to thank my program director, Dr. Damian Lee, for his unconditional support during all stages of my residency and for his modern vision and flexibility in my clinical formation in prosthodontics.
Vita

October 9, 1987 ......................................... Born, Maracaibo, Venezuela

2010 .......................................................... Doctor of Dental Surgery Degree
            The University of Zulia, Faculty of Dentistry
            Maracaibo, Venezuela

2012-present............................................... Graduate Resident
            Advanced Prosthodontics Program
            The Ohio State University, Columbus, OH

Publications


Fields of Study

Major Field: Dentistry

Prosthodontics
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Chapter One: Introduction

Edentulism, or the absence of teeth, contributes to disability, impairment, and handicap that significantly affect the general health and overall quality of life of an individual.\(^1\) Complete denture rehabilitation is the most traditional prosthodontic treatment for edentulous patients who have anatomical, psychological or financial restraints that contradict implant therapy; however, many essential treatment variables have not been scientifically validated.\(^2\) The estimated prevalence of complete edentulism, considered a fast growing public health problem in individuals older than 65 years in the United States, is approximately 26\%.\(^3\) Furthermore, a report on the expected need of prosthodontic treatment by Dorner et al stated that even in the most optimistic scenario of improvements in oral health, the percentage of people without teeth will only decrease 9% by the year 2020 and approximately 37.9 million adults are expected to be edentulous by the same year.\(^4\) A high level of patient satisfaction should be the primary goal in treating edentulous patients.\(^5\) Patient satisfaction is an important parameter to determine quality and success of
treatment. However many studies have demonstrated that patient satisfaction with complete dentures significantly decline overtime due to their fit and other factors. As a result, patient dissatisfaction translates into time loss for the dental practitioner. Nevertheless, it could be considered that patient satisfaction is a multicausal process involving objective and subjective factors such as age, sex, prosthetic experience, chewing ability, esthetics, retention, stability, comfort, degree of pain and the psychological/emotional status of the patient.

The methods of complete denture (CD) fabrication have remained relatively constant since the introduction of polymethylmethacrylate in 1936. Different techniques and methods have been described for fabricating CDs. The conventional protocol for fabrication involves a complex sequence of multiple clinical and laboratory steps ranging from preliminary impressions with irreversible hydrocolloid to final impressions made with elastomeric impression materials. Furthermore, additional appointments range from the registration of approximate maxillo-mandibular relationships with the use of wax record rims to the esthetic try-in of the provisional dentures with the artificial teeth set in the desired occlusal scheme. On average, this process involves at least five appointments; this is if the patient approves and accepts the overall esthetics at the trial insertion appointment before processing the dentures. Even though the conventional protocol for denture fabrication has been clinically predictable for over 70 years, other disadvantages include high treatment costs due to increased patient visits and varying laboratory
expenses and extended chair time.\textsuperscript{11} These inconveniences may discourage clinicians from offering CD rehabilitation as part of their services. Most CD therapy is provided by general practitioners and the findings of a recent study indicate that in the year 2010, in the United States alone, approximately 9 million dentures were fabricated and less than 5\% were fabricated by trained prosthodontists.\textsuperscript{12} Therefore, cost and time efficient CD fabrication protocols should be established without overlooking the fundamental concepts and still provide favorable outcomes for patients. Some studies advocate the use of a “simplified” CD technique which avoids the use of a face-bow transfer and eliminates border molding procedures.\textsuperscript{13} These studies found no difference in patient satisfaction, comfort and masticatory function between dentures made with traditional and simple techniques, demonstrating that time and costs were significantly reduced.\textsuperscript{14 15} Carlsson et al.\textsuperscript{16} concluded that there is no superiority in the traditional CD fabrication technique and that the simplified technique can still provide high quality treatment outcomes.

Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) has made significant contributions in the field of dentistry since its early introduction in the 1980s when Andersson combined the concepts of copy milling and rapid digitization of single fixed dental prostheses.\textsuperscript{17} This concept rapidly evolved and led to the creation of the Procera (Nobel Biocare) system. Similarly, Mörmann developed and marketed the CEREC 1 system (Sirona Dental Systems LLC, Charlotte, NC) which was able to fabricate durable
ceramic inlay restorations chair-side by intraoral scanning of the tooth preparation. Many reports have described the use of CAD/CAM technology to fabricate fixed, removable and implant supported prostheses. Conventional fixed dental prostheses such as inlays, onlays, full contour crowns and even interim restorations have been successfully fabricated using this technology. Dental practitioners and technicians have the availability of virtually designing and milling removable partial frameworks with systems such as 3Shape A/S (Copenhagen, Denmark). In addition, CAD/CAM fabricated implant supported prosthesis, single, multiple or full arch, have been widely used and documented in the literature. However, very few reports describe the use and application of CAD/CAM technology to the fabrication of conventional CDs. Intraoral scanning of edentulous arches poses a great challenge as the functional and dynamic movements of the soft tissues cannot be accurately captured in a digital form. Soft tissue displaceability also influences the quality of the direct digital impression. In a recent study by Patzelt et al., their findings suggested that the intra oral scanners used could not be recommended for digitizing edentulous jaws in vivo and that technological enhancement and further investigations were needed. Complete denture fabrication consists of multiple steps and appointments where records are obtained and evaluated in order to create a harmonious reestablishment of the patient’s function, phonetics and esthetics. The esthetic try-in appointment is often thought to be essential as the clinician has the ability to customize the arrangement of teeth
and confirm all the steps preceding this appointment (vertical dimension of occlusion, centric relation, lip support, incisal edge position, gingival display, amount of buccal corridor and coincidence of facial and maxillary midline). This appointment is a significant advantage of the conventional fabrication technique as modifications can be made chair-side and the patient can fully participate and be involved in the customization of their CDs.

A method for construction of CDs utilizing CAD/CAM technology has been previously suggested. This method has the potential to simplify and shorten the number of patient visits. Computer-aided technologies allow more precise and systematic modeling, and could therefore reduce the burdensome steps of both chair-side and laboratory work, saving vital clinical time. According to Bidra et al., the potential advantages of this type of technology include: 1) fabrication of CDs in only 2 clinical appointments whereby final impressions, maxillomandibular records and tooth selection are completed in one appointment; 2) superior strength and intimate fit of the dentures due to the use of pre-polymerized acrylic resin pucks; 3) reduced potential for dentures to harvest opportunistic microorganisms such as *candida albicans*; 4) reduced cost for the clinician and patient; and 5) ease of duplication of denture due to stored digital data. However, a potential disadvantage of this system is that prosthodontic concepts such as gothic arch tracing need to be mastered in order to efficiently utilize this technique. Assessing vertical dimension of occlusion and incisal edge position could
potentially be challenging for many practitioners. Furthermore, patients with severe skeletal discrepancies may not be candidates for this type of treatment modality. Even though some may consider this treatment as “controversial” due to the unconventionality of the technique, Bidra et al.\textsuperscript{13} advocated that CAD/CAM fabricated complete dentures can positively influence patient care, dental curriculums and research.

Currently, there are three available digital complete denture systems: AvaDent Digital Dentures (Global Dental Science LLC, Scottsdale, Ariz.), Dentca CAD/CAM System (Dentca Inc. Los Angeles, Calif.) and Pala Digital Dentures (Heraeus Kulzer, Hanau, Germany). These three systems claim that instead of following a five appointment conventional CD protocol, a two-appointment technique allows the clinician to make final impressions, record maxillo-mandibular relations and select tooth molds in one appointment. Using CAD/CAM technology, the CDs are fabricated and delivered in a second clinical visit.\textsuperscript{20} The CDs involved in this study were made using the AvaDent Digital Denture System (Global Dental Science LLC, Scottsdale, Ariz.) which uses laser scanning to digitize the final impressions and subtractive manufacturing to mill the denture bases using pre-polymerized acrylic resin cylinder. This block or “puck” has been produced under high pressure and heat (at 50 times the conventional processing pressure of conventionally processed CDs)\textsuperscript{24} and initial research has shown that the denture base material may have fewer adherences of microorganisms due to
the decrease in porosity. The technique presented describes how to obtain the necessary clinical information for digital complete denture fabrication in only 2 patient visits.

**TECHNIQUE**

1. If the patient has existing, acceptable CDs, a putty cast of the denture intaglions is made using the heavy consistency polyvinyl siloxane (PVS) material. (Figure 1.1)

2. Thermoplastic trays are selected and softened using a hot water bath at 77°C and are adapted onto the putty cast. If the patient does not have existing CDs, the trays can be customized intraorally according to the size of the patient’s residual alveolar ridge. (Figure 1.2 and 1.3)

3. Additionally, it must be confirmed that the trays have proper extensions once placed inside the patient’s mouth. Adjustments can be made chair side. The borders of the tray can be trimmed and adjusted using acrylic burs or Iris scissors.

4. After confirming adequate extension and adaptation of the trays, maxillary and mandibular functional border molding procedures are made using the
heavy body material and final impressions are made with the light body material. (Figure 1.4 and 1.5)

5. The vertical dimension of occlusion and vertical dimension of rest are assessed using the patient’s existing dentures (if available and are considered well-fitting by the clinician). If the patient does not have existing dentures, then the preferred method of assessment should be employed.25

The correct anatomic measuring device (AMD) is selected, coated with adhesive and using the fast set PVS maxillo-mandibular recording material, these are inserted intraorally and stabilized before making the appropriate registration. (Figure 1.6)

6. Once the maxillary and mandibular AMDs are correctly positioned inside the patient’s mouth, the AvaDent orientation ruler is attached with the purpose of aligning the maxillary AMD to the patient’s interpupillary line. This orientation ruler aids in the virtual articulation of the complete dentures with the use of software algorithms.16

7. The vertical dimension of occlusion can be adjusted using the driver provided in
the kit by raising or lowering the height of the central bearing pin. (Figure 1.7)

8. Guide the patient into centric relation multiple times before making the final tracing registration. To confirm centric relation with the gothic arch tracing, coat the tracing plate of the mandibular AMD with indicating occlusal spray (Oclude® Aerosol Indicator Marking Spray, Pascal International Inc.) (Figure 1.8)

9. Instruct the patient to “take their jaw back” or retrude their mandible and trace lateral, anterior and posterior excursive movements with the bearing pin. These movements will be transferred onto the marking agent on the mandibular AMD platform. (Figure 1.9)

10. In centric relation position, inject the registration PVS material between the AMD trays. (Figure 1.10) Adjust the lip support flange to provide proper fullness of the upper lip.

11. Fixate the acetate esthetic overlay with the simulated tooth position with flowable composite or stickers provided by the company to establish midline, gingival display and incisal edge position. (Figure 1.10)

12. The final impressions and interlocked AMDs are inspected for stabilization and sent to the company for fabrication of the complete denture prostheses. (Figure 1.11)

13. A digital preview is made available for the dentist to examine and make modifications if needed. (Figure 1.12)

14. Once the intaglio surface of the dentures and the denture tooth sockets are milled, the selected denture teeth are chemically bonded to the milled base by means of a
proprietary PMMA bonding agent. (Figure 1.13 and 1.14)

Figure 1.7: Adjustment of the VDO using the wrench to raise or lower the pin.

Figure 1.8: Once the proper VDO is established, guide the patient into CR position.

Figure 1.9: Gothic arch tracing reproduced on indicating material.

Figure 1.10: Stabilization of maxillary and mandibular AMDs with use of fast set PVS record material.

Figure 1.11: Disinfected maxillary and mandibular AMDs are secured and ready to be sent to company for fabrication of CDs.

Figure 1.12: Digital preview of virtual arrangement of denture teeth.
15. Final prosthesis ready to be delivered to the patient (Figure 1.15)

The perceived benefits from this digital denture system are many. One of the most significant advantages that the company claims over the conventional protocols of CD fabrication are the reduction in number of appointments and reduction in clinical chair time. This system incorporates a simplified method of obtaining final impressions and establishing maxillo-mandibular records in one appointment and final delivery in a second appointment. This method of CD fabrication claimed by the
company could prove to be a cost efficient treatment modality for edentulous patients and private practitioners. However, long term clinical data is lacking in the available literature regarding the true outcome of these prostheses. Prospective, standardized clinical studies involving CAD/CAM complete dentures are needed to improve patient centered care and to provide evidence based research. Therefore, the aims of this study were to: (1) evaluate practitioner experience with this CD system and relate experience with number of appointments for delivery and post insertion adjustment visits; (2) Evaluate overall patient satisfaction; (3) evaluate if incidence of treatment complications were related to operator skill. This retrospective study collected data from the charts of patients treated within the Pre-Doctoral Comprehensive Care Clinics, Advanced Prosthodontics Clinic and Dental Faculty Practice Clinic at The Ohio State University College of Dentistry. The collected chart data were evaluated for objective treatment outcomes such as: total number of appointments to deliver the final maxillary and mandibular complete dentures, the total number of post insertion adjustment visits and reported complications. The following null hypothesis were formulated: (1) no difference exists between operator experience (PRED, GRPR, DFP) and the total number of appointments required to deliver the prostheses and (2) no difference exists between operator experience and the frequency of complications. In addition, a thirteen item survey was designed and sent to the treated patients to evaluate their overall satisfaction with this type of prostheses.
Chapter 2: Materials and Methods

This study evaluated patients treated between the years 2012-2014 and received approval by The Ohio State University’s Biomedical Sciences Institutional Review Board (Protocol Number: 2014H0024) in November 2014. Inclusion criteria included edentulous patients who were seeking prosthodontic treatment in The Ohio State University College of Dentistry Clinics and had received treatment with the Avadent® system. The only exclusion criterion for this study was patients requiring immediate digital complete dentures. The study sample included 50 subjects, 25 female and 25 male patients, with ages ranging from 26-90 years with a mean average age of 62.64 years. The charts of all of the patients rehabilitated with digital CDs were considered for review. With the assistance of a dental software search tool (Windent EE; Carestream Dental), the number of CAD/CAM fabricated CDs (AvaDent® Global Dental Science LLC, Scottsdale, Ariz.) delivered was identified at the Pre-Doctoral Comprehensive Care Clinics, Advanced Prosthodontics Clinic and Dental Faculty Practice Clinic between the years 2012 and 2014. In addition, the company proportioned a list of all the patients who received their services within the dental clinics. The reviewed charts were associated with one or more of the
following CDT codes from the American Dental Association:

**5110**: Complete Denture Maxillary

**5120**: Complete Denture Mandibular

The chart of patients who have been associated with those billing codes were selected and reviewed by this author. Data was collected by a single examiner to avoid interexaminer variability. A data collection template was developed to facilitate and standardize the gathering of data from the patient’s clinical charts (Figure 2). The patients’ age and gender were recorded and each patient was assigned a study identification number in accordance with the federal Health Insurance Portability and Accountability Act (HIPAA) regulations. The number of post insertion adjustment visits and number of appointments needed to deliver the prostheses were recorded for each patient. If more than two appointments were needed to deliver the prostheses, the reasons were identified and recorded. The data collection template also included the most common CD complications and the incidences of these complications were recorded. Furthermore, the complications presented were associated to the level of experience of the clinician to evaluate if a relationship existed.

Out of the 50 total rehabilitated patients, 24 patients were treated at the predoctoral level, 24 were treated at the Graduate Prosthodontics resident level and the remaining 2 patients were treated by practicing faculty. A total of 94 digitally fabricated prostheses were delivered; 49 maxillary complete dentures, 35 mandibular complete dentures and 10 implant assisted overdentures.
In addition, thirteen statements regarding patients’ satisfaction with this treatment modality and outcome were listed and made available for the patient to complete. Patients were given the option to agree, remain neutral, or disagree with these statements (Figure 2.1). The results of the patient satisfaction questions were evaluated using descriptive statistics. The number of participants in the retrospective chart review portion and the survey information collection portion differed due to a 38% (19/50) response rate. The informed consent and HIPAA authorization were obtained for the survey portion of the study, however, the chart review was conducted under a waiver of consent and HIPAA authorization.

All statistical tests were performed using SAS Statistical Software (SAS Institute, Cary, NC). The relationship between the operator experience and the incidence of complications and number of appointments needed to deliver the prostheses were analyzed using the Mantel-Haenszel chi square test. The responses provided by the patient questionnaire analyzed using the Mantel-Haenszel chi square test. All results were assessed at 95% confidence intervals at a significance level of p<0.05.
Figure 2.1: Data Collection spreadsheet used for the retrospective aspect of the study.

<table>
<thead>
<tr>
<th>Total # of post insertion adjustment visits</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractured denture bases:</td>
<td>YES</td>
<td>NO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fractured/Debonded denture teeth:</td>
<td>YES</td>
<td>NO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replacement of denture teeth due to wear:</td>
<td>YES</td>
<td>NO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of retention:</td>
<td>YES</td>
<td>NO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need for lab processed hard relines:</td>
<td>YES</td>
<td>NO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chewing Ability:</td>
<td>Improved</td>
<td>Declined</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development of TMJ symptoms:</td>
<td>YES</td>
<td>NO</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Appointment needed to deliver denture</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Reason:</td>
<td>Requested walk in</td>
<td>Occlusion off</td>
<td>Balance off</td>
<td>Fit</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other Prosthetic Complications: N/A

Figure 2.2: Survey given to patients.

1. Your new dentures are better than your previous ones (if applicable).
2. Your ability to chew has improved with your new dentures.
3. Your smile with your new dentures looks nice.
4. Your speech has improved or remained the same with your new dentures.
5. Your new dentures are easy to clean compared to the old ones.
6. Your dentures fit well and they stay in place when you speak and eat.
7. Your expectations were fulfilled.
8. Your new dentures are comfortable.
9. This experience was worth your time, money and effort.
10. You would recommend these type of dentures to others.
11. You are satisfied overall with your new dentures.
12. The number of appointments it took for my denture construction was an improvement over the number required for my old ones.
13. Adjustment period to the new dentures was shorter than the adjustment period to the old dentures (if applicable).
Chapter 3: Results

The records of 50 patients were included in this study, (25 female and 25 male) between the ages of 26-90 with a mean of 62.64 years of age. There was no difference found in average ages of men and women included in this study (Table 3.1 and Table 3.2). A total of 24 patients were treated in the Graduate Prosthodontics Clinic, 24 were treated in the predoctoral Comprehensive Clinics and 2 patients were treated in the Dental Faculty Practice Clinics. (Table 3.3) A total number of 94 digital prostheses were delivered and distributed between the three providing clinics. A total of 44 patients received maxillary and mandibular prostheses, whereas 6 patients had only one arch rehabilitated (Table 3.4).

The mean number of appointments needed to deliver the prosthesis in all operator experience categories (PRED, GRPR, DFP) was 2.38 compared to the control number of appointments claimed necessary by the company established as 2 (Table 3.5, 3.6). The reasons it required more than two appointments to deliver the prostheses were noted and recorded. (Table 3.7) In reference to post insertion adjustment visits, the mean number for the sample population was 2.12 clinical visits due to the presence of ulcers or “sore spots” in which 32% of the patients treated required one post adjustment visit, followed by 28% of the patients requiring two visits and 12% requiring no adjustment at all (Table 3.8).
Table 3.1 compares the number of females and males in study.

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Std Err</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>25</td>
<td>64.0800</td>
<td>16.0492</td>
<td>3.2098</td>
<td>26.0000</td>
<td>90.0000</td>
</tr>
<tr>
<td>M</td>
<td>25</td>
<td>61.2000</td>
<td>8.8129</td>
<td>1.7626</td>
<td>44.0000</td>
<td>76.0000</td>
</tr>
<tr>
<td>Diff (1-2)</td>
<td></td>
<td>2.8800</td>
<td>12.9469</td>
<td>3.6619</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.2 shows the average ages for both genders and no statistical significance was found between groups.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Method</th>
<th>Mean</th>
<th>95% CL Mean</th>
<th>Std Dev</th>
<th>95% CL Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td></td>
<td>64.0800</td>
<td>57.4552</td>
<td>16.0492</td>
<td>12.5317</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>70.7048</td>
<td></td>
<td>22.3269</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>61.2000</td>
<td>57.5622</td>
<td>8.8129</td>
<td>6.8813</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>64.8378</td>
<td></td>
<td>12.2600</td>
</tr>
<tr>
<td>Diff (1-2)</td>
<td>Pooled</td>
<td>2.8800</td>
<td>-4.4828</td>
<td>12.9469</td>
<td>10.7967</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10.2428</td>
<td></td>
<td>16.1745</td>
</tr>
<tr>
<td>Diff (1-2)</td>
<td>Satterthwaite</td>
<td>2.8800</td>
<td>-4.5380</td>
<td>10.2980</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.3 shows the total number of patients treated by operator rank.

<table>
<thead>
<tr>
<th>Experience Level of Operator</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFP</td>
<td>2</td>
<td>4.00</td>
</tr>
<tr>
<td>GRPR</td>
<td>24</td>
<td>48.00</td>
</tr>
<tr>
<td>PRED</td>
<td>24</td>
<td>48.00</td>
</tr>
</tbody>
</table>
Table 3.4 shows the frequency of type of treatment provided to the patients included in the study.

<table>
<thead>
<tr>
<th>Prostheses Received</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>/OVD</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>CD/</td>
<td>3</td>
<td>6.00</td>
</tr>
<tr>
<td>CD/CD</td>
<td>35</td>
<td>70.00</td>
</tr>
<tr>
<td>CD/HYB</td>
<td>2</td>
<td>4.00</td>
</tr>
<tr>
<td>CD/OVD</td>
<td>9</td>
<td>18.00</td>
</tr>
</tbody>
</table>

Table 3.5 represents the frequency and percentage of appointments required to deliver the CDs in all clinics.

<table>
<thead>
<tr>
<th>Total Number of Appointments needed to Deliver Prostheses</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>33</td>
<td>66.00</td>
</tr>
<tr>
<td>3</td>
<td>16</td>
<td>32.00</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Table 3.6 exhibits the mean of appointments required to deliver the CDs for the patients included in this study.

<table>
<thead>
<tr>
<th>R-Square</th>
<th>Coeff Var</th>
<th>Root MSE</th>
<th>Mean Total Appointments to Deliver Prostheses</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.027465</td>
<td>25.48546</td>
<td>0.606554</td>
<td>2.380000</td>
</tr>
</tbody>
</table>

Of the 94 arches completed, 23 could not be delivered at the second appointment. For this, the most common reported reason were lack of retention (9/23) and incorrect vertical
dimension of occlusion (4/23). All 23 dentures not delivered in the second appointment were delivered at the third appointment.

Table 3.7 exhibits the frequency and percentage of the reasons why the prostheses could not be delivered to the patients in 2 clinical visits.

<table>
<thead>
<tr>
<th>Reasons for Delivery in &gt;2 appointments</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esthetics Off</td>
<td>3</td>
<td>13.04</td>
</tr>
<tr>
<td>Phonetics Off</td>
<td>1</td>
<td>4.34</td>
</tr>
<tr>
<td>Lack of Retention</td>
<td>9</td>
<td>39.13</td>
</tr>
<tr>
<td>Incorrect Vertical Dimension of Occlusion</td>
<td>4</td>
<td>17.39</td>
</tr>
<tr>
<td>Incorrect Centric Relation</td>
<td>3</td>
<td>13.04</td>
</tr>
<tr>
<td>Operator Requested Wax Try In Denture</td>
<td>2</td>
<td>8.69</td>
</tr>
<tr>
<td>Fracture at overdenture locator interface</td>
<td>1</td>
<td>4.34</td>
</tr>
</tbody>
</table>

Table 3.8 exhibits the frequency and percentage of post insertion adjustment visits required for the patients included in this study.

<table>
<thead>
<tr>
<th>Number of Post Insertion Adjustment Visits</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6</td>
<td>12.00</td>
</tr>
<tr>
<td>1</td>
<td>16</td>
<td>32.00</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>28.00</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>12.00</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>4.00</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>6.00</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>2.00</td>
</tr>
</tbody>
</table>
Out of the 50 patients included in this study, a total of 17 patients required more than two clinical appointments to deliver the final prostheses. Fifteen patients presented complications the day of delivery that required additional appointments. The other two patients had an esthetic try-in appointment, requested by the operator, which increased the number of total appointments. A total of four patients presented with more than one complication and the frequencies of common complication in terms of total number of arches completed were (Table 3.9):

- 9.57% (9/94) — lack of retention
- 4.25% (4/94) — Incorrect vertical dimension of occlusion
- 3.19% (3/94) — Unacceptable esthetics
- 3.19% (3/94) — Incorrect centric relation

Those patients who had inadequate retention the day of delivery had either a soft reline with a temporary denture lining material (3/17) or had a laboratory processed reline that required an additional visit for delivery (6/17). The patients that exhibited increased vertical dimension of occlusion required re-milling of the prostheses or adjustment of the dentures by remounting procedures. Five patients required the dentures to be remade following the conventional technique (5/17). One of the patients in the remake group developed a possible allergic reaction to the denture material that was characterized by sloughing of the epithelium. The esthetic concerns involved described in the chart progress notes involved deviated maxillary midlines.
and excessive gingival display. In terms of the management of the clinical complications mentioned above, the following procedures were performed to mitigate or solve the clinical problems encountered are summarized in Table 3.9:

<table>
<thead>
<tr>
<th>Complications</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab Processed Relines</td>
<td>6</td>
<td>35.29</td>
</tr>
<tr>
<td>Remakes to Conventional CDs</td>
<td>5</td>
<td>29.41</td>
</tr>
<tr>
<td>Soft Denture Reline</td>
<td>3</td>
<td>17.64</td>
</tr>
<tr>
<td>Repair of fractured OVD</td>
<td>1</td>
<td>5.88</td>
</tr>
<tr>
<td>Hard reline of Palate to Improve Speech</td>
<td>1</td>
<td>5.88</td>
</tr>
<tr>
<td>Possible allergic reaction to material</td>
<td>1</td>
<td>5.88</td>
</tr>
</tbody>
</table>

Table 3.9 shows the most common complications noted during the retrospective aspect of the study.

A total of 33 patients (66% of the sample size) treated in PRED, GRPR and DFP presented no complications during and after completing their complete denture therapy. A total of 17 patients presented with at least one complication representing 34% of the treated patients. In regards to operator experience and the incidence of complications with these prostheses, the Mantel-Haenszel chi square test was used and no difference was found for the occurrence of complications in relation to the operator experience (p=0.06) (Tables 3.10, 3.11).

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Table 3.10 illustrates the number of complications according to operator experience level where “0” means no complications were documented.

<table>
<thead>
<tr>
<th>Complication</th>
<th>PRED</th>
<th>GRPR</th>
<th>DFP</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>16</td>
<td>16</td>
<td>1</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>32.00</td>
<td>32.00</td>
<td>2.00</td>
<td>66.00</td>
</tr>
<tr>
<td></td>
<td>48.48</td>
<td>48.48</td>
<td>3.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>66.67</td>
<td>66.67</td>
<td>50.00</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>8</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>16.00</td>
<td>16.00</td>
<td>2.00</td>
<td>34.00</td>
</tr>
<tr>
<td></td>
<td>47.06</td>
<td>47.06</td>
<td>5.88</td>
<td></td>
</tr>
<tr>
<td></td>
<td>33.33</td>
<td>33.33</td>
<td>50.00</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>24</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>48.00</td>
<td>48.00</td>
<td>4.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Table 3.11 shows the statistical analyses and values obtained for the chi square test (p=0.006)

<table>
<thead>
<tr>
<th>Statistic</th>
<th>DF</th>
<th>Value</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td>2</td>
<td>0.2377</td>
<td>0.8880</td>
</tr>
<tr>
<td>Likelihood Ratio Chi-Square</td>
<td>2</td>
<td>0.2256</td>
<td>0.8933</td>
</tr>
<tr>
<td>Mantel-Haenszel Chi-Square</td>
<td>1</td>
<td>0.0617</td>
<td>0.8039</td>
</tr>
<tr>
<td>Phi Coefficient</td>
<td></td>
<td>0.0689</td>
<td></td>
</tr>
<tr>
<td>Contingency Coefficient</td>
<td></td>
<td>0.0688</td>
<td></td>
</tr>
<tr>
<td>Cramer's V</td>
<td></td>
<td>0.0689</td>
<td></td>
</tr>
</tbody>
</table>
The total number of appointments needed to deliver the prostheses depending on operator experience is displayed in Table 3.30. The results of the chi square test showed that there was no statistical difference regarding operator experience in terms of the number of appointments needed to deliver the digital prostheses $p=0.88$. (Table 3.12 and 3.13)

Table 3.12 shows number of appointments needed to deliver the dentures according to operator skill

<table>
<thead>
<tr>
<th>Rank Operator Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRED</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>48.48</td>
</tr>
<tr>
<td>66.67</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>50.00</td>
</tr>
<tr>
<td>33.33</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>0.00</td>
</tr>
<tr>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Statistics for Table of Total__appts_to_deliver_prosth by RankOperatorExperience

<table>
<thead>
<tr>
<th>Statistic</th>
<th>DF</th>
<th>Value</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td>4</td>
<td>2.1465</td>
<td>0.7088</td>
</tr>
<tr>
<td>Likelihood Ratio Chi-Square</td>
<td>4</td>
<td>3.1233</td>
<td>0.5374</td>
</tr>
<tr>
<td>Mantel-Haenszel Chi-Square</td>
<td>1</td>
<td>0.0219</td>
<td>0.8824</td>
</tr>
<tr>
<td>Phi Coefficient</td>
<td></td>
<td>0.2072</td>
<td></td>
</tr>
<tr>
<td>Contingency Coefficient</td>
<td></td>
<td>0.2029</td>
<td></td>
</tr>
<tr>
<td>Cramer's V</td>
<td></td>
<td>0.1465</td>
<td></td>
</tr>
</tbody>
</table>

Tables 3.13 demonstrate no statistical difference between the operator skill and the number of appointments required to deliver the final prostheses.
In regard to the subjective aspect of this study, a total of 19 patients returned their completed surveys along with a signed waiver of consent and HIPAA authorization form. The total patient response rate after treatment intervention was 38%. In reference to the statements on patient satisfaction, 78.95% agreed that they were pleased with the esthetics of their dentures (Table 3.14); 78.57% agreed that their new digital complete dentures were “better” than their previous set of dentures (Table 3.15); 73.68% agreed with being satisfied with their new dentures (Table 3.16); 68.75% agreed that their new dentures were easy to clean (Table 3.17); 68.42% agreed that they considered their dentures as “comfortable” and that they would recommend digital complete dentures to others (Tables 3.18 and 3.19); 63.16% agreed that their expectations were fulfilled and that this experience was worth their time, efforts and money (Table 3.20); 57.89% agreed that their speech and chewing ability had improved with the use of digital dentures (Tables 3.21 and 3.22); 56.25% of agreed that the reduced number of appointments required for denture fabrication was an improvement (Table 3.23); 53.33% agreed that the adjustment period to the digital dentures was shorter than with their previous dentures (Table 3.24); and 52.63% agreed that their dentures fit well and stayed in place during function (Table 3.25).
Table 3.14 shows patient responses regarding their denture esthetics.

<table>
<thead>
<tr>
<th>Pleased with Denture Esthetics</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Agree</td>
<td>15</td>
<td>78.95</td>
</tr>
<tr>
<td>2-Neutral</td>
<td>1</td>
<td>5.26</td>
</tr>
<tr>
<td>3-Disagree</td>
<td>3</td>
<td>15.79</td>
</tr>
</tbody>
</table>

Table 3.15 shows patient responses comparing their new dentures to their conventional set.

<table>
<thead>
<tr>
<th>New CDs Better than Old CDs</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Agree</td>
<td>11</td>
<td>78.57</td>
</tr>
<tr>
<td>2-Neutral</td>
<td>1</td>
<td>7.14</td>
</tr>
<tr>
<td>3-Disagree</td>
<td>2</td>
<td>14.29</td>
</tr>
<tr>
<td>N/A</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
Table 3.16 shows patient responses to overall satisfaction with their new complete dentures.

<table>
<thead>
<tr>
<th>Overall Satisfaction</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Agree</td>
<td>14</td>
<td>73.68</td>
</tr>
<tr>
<td>2-Neutral</td>
<td>1</td>
<td>5.26</td>
</tr>
<tr>
<td>3-Disagree</td>
<td>4</td>
<td>21.05</td>
</tr>
</tbody>
</table>

Table 3.17 shows patient responses to ease of cleaning their new complete dentures.

<table>
<thead>
<tr>
<th>Ease of CD Cleaning</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Agree</td>
<td>11</td>
<td>68.75</td>
</tr>
<tr>
<td>2-Neutral</td>
<td>3</td>
<td>18.75</td>
</tr>
<tr>
<td>3-Disagree</td>
<td>2</td>
<td>12.5</td>
</tr>
<tr>
<td>N/A</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.18 shows patient responses in regards to comfort.

<table>
<thead>
<tr>
<th>Comfort of CDs</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Agree</td>
<td>13</td>
<td>68.42</td>
</tr>
<tr>
<td>2-Neutral</td>
<td>2</td>
<td>10.53</td>
</tr>
<tr>
<td>3-Disagree</td>
<td>4</td>
<td>21.05</td>
</tr>
</tbody>
</table>
Table 3.19 shows patient responses in regards to recommending the experience and treatment to others.

<table>
<thead>
<tr>
<th>Recommend to Others</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Agree</td>
<td>13</td>
<td>68.42</td>
</tr>
<tr>
<td>2-Neutral</td>
<td>2</td>
<td>10.53</td>
</tr>
<tr>
<td>3-Disagree</td>
<td>4</td>
<td>21.05</td>
</tr>
</tbody>
</table>

Table 3.20 shows patient responses in regards to their expectations being fulfilled.

<table>
<thead>
<tr>
<th>Expectations, Time, Money and Efforts Fulfilled</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Agree</td>
<td>12</td>
<td>63.16</td>
</tr>
<tr>
<td>2-Neutral</td>
<td>4</td>
<td>21.05</td>
</tr>
<tr>
<td>3-Disagree</td>
<td>3</td>
<td>15.79</td>
</tr>
</tbody>
</table>

Table 3.21 shows patient responses in terms of improved speech and phonetics.

<table>
<thead>
<tr>
<th>Improved Speech</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Agree</td>
<td>11</td>
<td>57.89</td>
</tr>
<tr>
<td>2-Neutral</td>
<td>4</td>
<td>21.05</td>
</tr>
<tr>
<td>3-Disagree</td>
<td>4</td>
<td>21.05</td>
</tr>
</tbody>
</table>
### Table 3.22

<table>
<thead>
<tr>
<th>Improved Chewing</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Agree</td>
<td>11</td>
<td>57.89</td>
</tr>
<tr>
<td>2-Neutral</td>
<td>4</td>
<td>15.79</td>
</tr>
<tr>
<td>3-Disagree</td>
<td>4</td>
<td>26.32</td>
</tr>
</tbody>
</table>

Table 3.22 shows patient responses in terms of improved masticatory function.

### Table 3.23

<table>
<thead>
<tr>
<th>Improvement in the decrease of Total # of Appointments</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Agree</td>
<td>9</td>
<td>56.25</td>
</tr>
<tr>
<td>2-Neutral</td>
<td>3</td>
<td>18.75</td>
</tr>
<tr>
<td>3-Disagree</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>N/A</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.23 shows patient responses in regards to improvement in the reduction of number of total appointments.

### Table 3.24

<table>
<thead>
<tr>
<th>Adjustment Period to new CDs shorter than Previous CDs</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Agree</td>
<td>8</td>
<td>53.33</td>
</tr>
<tr>
<td>2-Neutral</td>
<td>5</td>
<td>33.33</td>
</tr>
<tr>
<td>3-Disagree</td>
<td>2</td>
<td>13.33</td>
</tr>
<tr>
<td>N/A</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.24 shows patient responses in regards to their adjustment period to their new prostheses.
Table 3.25 shows patient responses in regards to their experience with the overall fit of the dentures.

<table>
<thead>
<tr>
<th>Good overall fit of CDs</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Agree</td>
<td>10</td>
<td>53.33</td>
</tr>
<tr>
<td>2-Neutral</td>
<td>3</td>
<td>33.33</td>
</tr>
<tr>
<td>3-Disagree</td>
<td>6</td>
<td>13.33</td>
</tr>
</tbody>
</table>

In addition, Figures 3.1, 3.2 and 3.3 provide a complete comparison of patient answers to the items listed on the questionnaire.

Figure 3.1 compares patient responses to the different items provided on the survey.
Figure 3.2 provides cumulative results regarding patient satisfaction statements.

Figure 3.3 provides cumulative results regarding patient satisfaction statements.
Table 3.26 shows that there was a significant difference between patient’s perceptions of their new dentures as more improved versus their previous dentures.

Of the 14 experienced denture wearers that responded to the survey, 8 patients received maxillary and mandibular CAD/CAM fabricated CDs, 2 patients received a CAD/CAM fabricated maxillary CD, 3 patients received CAD/CAM fabricated maxillary CD opposing a CAD/CAM implant assisted overdenture and one patient received only a mandibular CAD/CAM fabricated implant assisted overdenture. The eleven patients that agreed that their new prostheses were better than their previous conventional CDs, 7 patients were treated by Graduate Prosthodontics residents and 4 patients were treated by predoctoral students. The patients that received implant supported prostheses were excluded from the statistical analysis for standardization of the data. Nine patients received maxillary and mandibular CDs and two patients received maxillary CDs. Chi square test revealed no statistically significant difference (p=.180) in these ratings for these 9 patients even though 77.8% of these 9 patients

<table>
<thead>
<tr>
<th>Chi-Square Test for Equal Proportions</th>
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<tbody>
<tr>
<td>Chi-Square</td>
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<tr>
<td>DF</td>
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<tr>
<td>Asymptotic Pr &gt; ChiSq</td>
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<td>Exact Pr &gt;= ChiSq</td>
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</tbody>
</table>
agreed that their new CD or CD set was better. (Table 3.27 and 3.28)

Table 3.27 shows the total number of experienced CD (non-implant) wearers that responded to the survey

Table 3.28 shows the representing p value as 0.180
Chapter 4: Discussion

The first hypothesis of this study, that “operators with higher experience level achieved delivery of the prostheses in two clinical visits compared to non-experience operators” was rejected (p=0.88). The number of patients treated in the Advanced Prosthodontics Clinic and predoctoral Comprehensive Care Clinics were similar and having the advantage of faculty supervising and guiding the operators with the technical steps could have influenced the similar mean number of appointments needed to deliver the prostheses at all three operator experience levels. Nonetheless, it could be argued that CD rehabilitation is a forgiving, reversible treatment modality and efficient troubleshooting on the day of denture delivery could have been performed.

In a recent systematic review, Bidra et al. could not identify any case reports or clinical trials on CAD/CAM fabricated complete dentures. In addition, Kattadiyil et al cautioned that, for objective comparison of CAD/CAM CDs with conventionally fabricated dentures, more research is needed to obtain evidence-based/scientific assessment of this new concept of treatment. Other simplified protocols for complete denture fabrication have been previously suggested.\textsuperscript{26} Several studies have shown that the traditional protocols for complete denture fabrication had no superiority over the simplified protocols.\textsuperscript{23, 27} A recently published systematic review revealed no difference in masticatory variables, patient satisfaction or quality of the conventional
dentures constructed with the traditional or simplified methods. This CAD/CAM method of treatment allows for the completion of complete dentures in two clinical visits which provide inherent advantages. These include reduced clinical chair time for the patient, simplification of laboratory work and steps, and less number of patient visits required to fabricate a high quality end product. This method of CD fabrication appears to be a promising, cost efficient treatment modality for clinicians, compared to the need of at least five clinical visits, additional post insertion adjustment visits and multiple laboratory steps involved in the conventional method of denture fabrication.

One of the most significant advantages of CAD/CAM fabricated complete dentures involve the recording and transferring of clinical information in two clinical visits to produce a high quality, high performance prostheses that re-establishes the patient’s function, esthetics and phonetics harmoniously. The results of this study indicated that the mean number of appointments needed to deliver CAD/CAM fabricated prostheses in all three levels of operator experience (PRED, GRPR, DFP) was 2.38. It was also found that there is no statistically significant difference between operator skill and the number of appointments required to deliver the dentures. When compared to the conventional methods of complete denture fabrication, which involve at least five clinical visits, the findings suggest a considerable reduction in the total number of appointments needed. This finding is clinically significant as practitioners can reduce the amount of complete denture patient visits and laboratory work which translate into a beneficial, cost efficient treatment method to offer. This,
in turn, may indicate that, regardless of the operator training and expertise, this method of complete denture fabrication is applicable and predictable.

The second hypothesis of this study that the number or incidence of complications observed with these prostheses was influenced by operator experience was rejected. (p=0.0617). A similar number of complications were observed in both the PRED and GRPR level. This fact could be attributed to the technicalities and learning curve associated with this relatively new method of complete denture construction that students are not clinically adept. However, the predoctoral students received a certain degree of training and exposure to this system prior to using it through the use of informative materials and shadowing of the clinical steps involved with another student or faculty member. This way, efforts are made by the clinical faculty to calibrate the students for when they are to use this system for their edentulous patients. In addition, the methods of registering centric relation are taught in predoctoral curriculums; however, these are not emphasized throughout their clinical formation. It could also be hypothesized that both groups have the similarity that they are in a learning institution trying to develop and perfect their prosthodontic clinical skills.

In the present study, the most frequently encountered significant complication was lack of retention the day of denture delivery (9/23), followed by increased vertical dimension of occlusion (4/23) and these findings are in accordance with other results of previous studies.29 Therefore, the need for laboratory processed functional relines (35.29%) and placement of soft, interim denture liners (17.64%) were
necessary to overcome these clinical problems. The reasons for the high prevalence of lack of retention the day of delivery may have been influenced by improperly made edentulous final impressions. Both dental students and graduate students are taught different edentulous final impression techniques (functional vs. non functional impression techniques) and this, along with operator inexperience, could have influenced the overall quality of the final impression sent to the company for scanning and consequent milling of the denture bases. In addition, the company claims that the fit of the dentures is superior to that of a conventionally fabricated denture base because of the method of processing the acrylic resin for the denture base. Therefore, a posterior palatal seal is not required because there is no polymerization shrinkage of the acrylic resin but may be requested in the prescription order. The absence of a posterior palatal seal and an underextended/overextended final impression could have also influenced the retention of the prostheses the day of delivery.

An intolerable increase in vertical dimension of occlusion in denture prosthodontics may lead to the onset of tension in functional speech along with clicking of the denture teeth, difficulty in swallowing, impaired chewing and temporomandibular dysfunction. In this study, the patients that received complete dentures with inappropriate vertical dimension of occlusion (increased) and incorrect centric relation required clinical remount procedures and/or redesigning and remilling of the prostheses. Two out of the five patients that required remaking of the prostheses with the conventional method had increased vertical dimension of
occlusion. One patient developed a suspected allergic reaction to the digital prostheses characterized by epithelium sloughing that required remaking to conventional complete dentures. The remaining two patients had previous extractions performed and after less than a two month healing period before final impressions were made to begin the digital denture fabrication. The notes from these patient’s charts describe inadequate retention the day of prosthesis delivery, requiring soft temporary relines with tissue conditioning materials (Lynal® Tissue Conditioner and Temporary Reliner Kit, Dentsply Caulk). Eventually, both patients’ required new prostheses fabricated following the conventional methods. Research shows that complete socket calcification is complete at 8 to 12 months following tooth extractions and bone volume of the ridge is reduced 20% to 30% the first year. Therefore, a two month period post extractions could be considered insufficient healing time to fabricate definitive digital complete dentures or any denture for that matter. Therefore, the digital CD fabrication method cannot be held responsible for producing an ill-fitting prosthesis as traditional post extraction guidelines were not followed initially.

Several studies have proposed that patients have positive perceptions on complete denture therapy. The level of patient satisfaction has been associated with age, gender, prosthetic experience and psychological factors. Drago determined that post insertion denture adjustments for conventional complete denture patients are a multifactorial and complex phenomenon. In his retrospective clinical study, it was determined that the average number of adjustment visits was 2.86 for patients treated
with a traditional and modified impression technique in complete denture therapy. In this present study, the mean post insertion adjustment visits for the sample size was considered less than the previous findings at 2.12. Other studies have found similar numbers of post insertion adjustment recall visits.\textsuperscript{34} Eighty eight percent (44/50) of the patients treated required at least one post insertion adjustment visit. These finding are similar to the results of Kivovics et\textsuperscript{al} and Sadr et al\textsuperscript{36} in which 85.8% and 87% of patients required adjustments in the first 24 hours after insertion, respectively. One study found a correlation between the number of post-delivery adjustments and patient satisfaction levels, in which, the lower the number of recall visits, higher scores were obtained for patient satisfaction.\textsuperscript{27} The results of this study do not agree with other findings which concluded that the number of complete denture adjustments required after denture delivery is more in the case of junior practitioners than in the case of senior clinicians.\textsuperscript{37}

The third hypothesis of this study that the “experienced CD subjects” would agree that their new digital complete dentures were better than their previous CDs was rejected. The patients that received implant supported prostheses were excluded from the statistical analysis for standardization of the data. Nine patients received maxillary and mandibular CDs and two patients received maxillary CDs. Chi square test revealed no statistically significant difference (p= .180) in these ratings for these 9 patients even though 77.8% of these 9 patients agreed that their new CD or CD set was better. In general, out of the thirteen items listed on the questionnaire, the 19 study patients that returned the completed survey had positive responses in regards to
their overall experience with these types of prostheses. Several studies have shown that most patients are "reasonably satisfied" and "very satisfied" with their complete dentures.\textsuperscript{38} Based on the survey results, there is a tendency among the experienced denture wearers that their new CDs were better than their old ones. However, a large sample is needed to prove their ratings as significantly different.

The fact that experienced denture wearers found their new complete dentures to be “better” and “improved” in comparison to their old conventional set, these findings are in agreement with a recent randomized clinical trial performed at University of Detroit Mercy School of Dentistry in which they found that, after a one month follow up period, most patients preferred digital dentures over their traditional dentures.\textsuperscript{39}

There are some limitations associated to this retrospective study. One important limitation is the reduced number of patient responses for the subjective aspect of this study (n=19). In order to achieve statistically significant differences between digital CDs compared to conventional CDs in respects to patient satisfaction and preference, a higher number of patient responses would have been beneficial. In addition, it would have been ideal to compare this study’s sample with a conventional complete denture group to assess true clinical outcomes. This, in turn, could have lead to conducting a true randomized trial thus providing the highest level of evidence. The retrospective chart portion of this study also has its limitations, such as omitted information and subjective clinical documentation. Another limitation associated to this study is the length of the time frame in which the retrospective chart data collection occurred. Updated clinical chart notes could have been added, if scheduled
follow-up chart reviews were performed after the original data was collected, to verify its reliability and lack of variability. Comprehensive clinical data on digital complete dentures that meets the expectations of an evidence based clinical outcome, do not exist in the available literature. There is a pressing need to improve and enhance dental education of CDs by incorporating digital technology without disregarding the basic fundamentals and principles. Even thought the conventional technique of complete denture fabrication has been clinically predictable for over one hundred years\textsuperscript{13}, clinical and laboratory research is needed to improve the associated disadvantages to this technology. Some studies have described the use and development of face simulating technology which can potentially assist in determining the shape of dentures and arrangement of artificial denture teeth.\textsuperscript{40} Once the disadvantages associated with the current design softwares and programs are overcome, CD fabrication could be expected to be commercially manufactured by medical informatics instead of dental technicians.\textsuperscript{19} Prospective and standardized clinical studies involving more patients requiring CAD/CAM complete dentures are needed to improve patient care and to provide evidence based research that address treatment outcomes.\textsuperscript{13} Further research is needed, with a higher level of evidence, substantial sample sizes and adequate follow-up periods to validate the behavior and performance of this treatment alternative.\textsuperscript{25} Regardless of the methods of fabrication and delivery, the ultimate goal with any prosthodontic rehabilitation is to obtain favorable and successful patient outcomes with high levels of overall patient satisfaction.
Chapter 5: Conclusion

The following conclusions can be drawn from this retrospective study:

1. The mean number of appointments to deliver CAD/CAM fabricated CDs was 2.38 and number of post insertion appointments was 2.12.

2. No differences were found for number of appointments required to deliver CAD/CAM fabricated CDs in relation to operator experience. (p=.088)

3. No differences were found for the number or incidence of a complication in relation to operator experience. (p=0.0617)
Disclaimer

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