COMPLETE DENTURE OCCLUSION:

INTRA AND INTER OBSERVER ANALYSIS

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ABSTRACT

Aim: The aim of this study was to investigate the accuracy, intra- and inter-observer reliability of identifying occlusal markings made by articulating paper on complete dentures intra-orally.

Methods: A series of photographs of 14 tissue borne complete dentures with occlusal markings was obtained. Articulating paper was used intra-orally at the delivery visit to make the occlusal markings. The denture sets were divided into two groups. Group 1 comprised pictures of the 14 complete lower dentures on their own, and group 2 comprised pictures of the same 14 lower dentures together with their opposing upper denture. The two groups of images were loaded into a Microsoft PowerPoint presentation as well as Keynote. Two experienced observers analysed the complete dentures independently and noted the number and distribution of the markings that they felt required adjustment. They differed, but discussed these and reached consensus. These data served as the control. Three groups of observers (10 per group) were then asked to analyse the occlusal markings of the 2 groups of denture images twice, with a two-week interval between each assessment. Before each subsequent assessment, the images were randomised by means of computer-generated random number sequence. The mean number of markings was established for each group and compared with the control mean. Intra-rater reliability was established by comparing the difference of the means of sequential observations for each rater by establishing the z-value. Inter-rater reliability within each group was established by means of analysis of variance.

Results: Considering all the data, in only 17 instances (of the possible 60), did observers' mean scores not differ from the control mean scores with good intra-rater reliability. In all other 43 instances the observers' mean scores differed from the control mean scores and/or displayed poor intra-rater reliability. Considerable variation in inter-rater reliability was also found within every group of observers.

Conclusion: The results indicate that observers are generally unable to reliably identify occlusal markings warranting occlusal adjustment, made by articulating paper on a lower complete denture.

Clinical significance: Articulating paper should not be used intra-orally when delivering removable complete dentures.

Keywords

Complete dentures, articulating paper, occlusal markings, intra-rater reliability, inter-rater reliability.

DECLARATION

I declare that this dissertation "*Complete denture occlusion: Intra and inter observer analysis*" is my own work, that it has not been submitted for any degree or examination in any other university, and that all sources I have used or quoted have been indicated and acknowledged by complete references.

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Sandile Khayalethu Derrick Mpungose

24 February 2014

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DEDICATIONS

I dedicate this to my family for their unconditional love, support and sacrifice which continues to propel me in achieving all my dreams.

- To my wife, **Dr Nhlanhla Duma**, for your unconditional love, understanding, constructive critism and support.
- My mother, **Ntombenhle Mpungose** and Sister, **S'bu Mpungose**, for your unconditional love and for always being my number one fan.
- My supervisor, **Prof. G Geerts**, for the advice, guidance, and always availing yourself.
- My beautiful children, **ZeKhethelo** & **Lukhetho** for the unconditional love and understanding.

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: LITERATURE REVIEW

1.1. INTRODUCTION

Tissue supported complete dentures (CDs) are a common treatment modality in clinical practice. When clinicians construct tissue supported CDs, the underlying rationale is to replace the missing/deficient oral tissue with a prosthesis that is functional, aesthetic and improves the oral health related quality of life. A prosthesis that is uncomfortable and causes pain for the individual will often require post insertion adjustments, and if there is gross discomfort it may even be rejected.

Occlusal adjustments of prostheses, at insertion or at recall visits, are common in clinical practice. With tissue supported CDs, one may choose to use an intra-oral technique or a clinical remount (Firtell et al. cited by Shigli et al, 2008). In some instances one may choose to use both techniques. With both techniques an appropriate occlusal indicating material must be used to allow the clinician to visualise and adjust the premature or interfering occlusal contacts.

There are several occlusal indicating materials that can be used to evaluate occlusal contacts in the construction of tissue supported CDs. The material most commonly used, due to its being readily available, economic and 'easy' to interpret, is occlusal indicating paper. There are several different thicknesses of occlusal indicating paper, and they also come in different colours.

The proper understanding of the nature of occlusal indicating materials, may allow the clinician to choose the appropriate occlusal indicator under varying clinical scenarios. It may also have a positive impact by ensuring that clinicians do not become over-zealous in occlusal adjustments, thus maintaining the integrity of the prosthesis.

1.2. LITERATURE

1.2.1. Edentulism and complete dentures

Globally, edentulism remains a serious health-care burden. Internationally, the incidence of edentulism is estimated to be between 7% and 69% (Petersen et al. cited by Felton, 2009). In the USA 26% of adults between the ages of 65-69 years were completely edentulous. In contrast complete edentulism was only at 6% in Africa (Polzer et al., 2010).

There is a lack of prosthetic epidemiological data in most developing countries. South African data has been confined to a few cross-sectional surveys conducted in convenience samples of the elderly in the Western Cape population (Van Wyk et al., 1977 and Watermeyer et al., 1981). Edentulism was highest amongst the "Cape Coloured" population in South Africa, with a prevalence of 56.8%. Unlike the USA population sample, the age group most affected in South Africa was that between the ages 35-44 years in the low socioeconomic and education groups (Louw & Moola, 1979). These results were confirmed by a later study by Du Plessis et al. (1989) which found that amongst the different ethnic groupings in South Africa the "Coloured" population had the highest prevalence (25%) of edentulism, followed by Whites (18%), Indians (2%), urban Blacks (2%) and rural Blacks (1%).

The Western Cape Province is unique in its position as the province in South Africa with the highest life expectancy, a population change rate that is double the national average, and a higher than average older population (PGWC, Department of Health. 2010 Strategic Plan 2010-2014). In viewing these trends it can be extrapolated with caution that edentulism and denture use will still have an impact in South Africa and in particular the Western Cape.

Tissue-born CDs are a common treatment modality for edentulism in South Africa. The manufacturing of new CDs was reported to have a positive impact on the oral health related quality of life of a sample population of CD-wearers in the Western Cape (Adam et al., 2007).

However, CDs are not without problems. There are many factors that may affect the success of complete dentures. To minimize bone loss, mucosal irritation and functional problems, Felton (2009) recommended that "exemplary" CD therapy should be provided to edentulous patients.

1.2.2. Complete denture occlusion

The objective with CD occlusion is to establish simultaneous bilateral contact on all posterior teeth when the mandible is closed in a centric relation position (Jacobson & Krol, 1983). This is considered a minimum requirement for whatever occlusal scheme the clinician may select for the CDs. The management of the occlusion in CDs is said to have a direct impact on the stability of the prostheses (Jacobson & Krol, 1983).

A well-balanced occlusion is one aspect of CD therapy that may contribute to patient adaptation (Shigli et al., 2008). This finding is supported by Goiato et al. (2011) who stated that "occlusal adjustment should preserve the artificial teeth where possible, in so doing this will improve the masticatory efficiency." On the other hand, occlusal disharmony may present as trauma on the denture-bearing areas due to the denture shifting to accommodate the interferences, causing uneven pressure on the denture-bearing tissues (Ansari, 1996). Goiato et al (2011) further stated that "neglect of occlusal adjustment, such as premature or sliding contacts, may jeopardise denture stability and retention which affects masticatory function, comfort and maintenance of the residual ridge".

"Occlusal disharmony prevalent in new CDs can result from warping of the record bases, errors in recording the maxillo-mandibular relationship, and errors in mounting procedures, or processing changes" (Shigli et al., 2008). Even though laboratory procedures may minimize the need for occlusal adjustments of CDs at delivery, it is doubtful that it can be completely eliminated, due to the resilient properties of denture-bearing and temperomandibular joint tissues as compared to the rigid nature of casts and articulators.

Any occlusal disharmony in CDs should be clinically corrected by occlusal refinement of the offending tooth/teeth. The offending surfaces must first be identified by means of an appropriate occlusal indicating tool. Clinically assessing the desired and undesired occlusal contacts may be achieved through the use of occlusal indicating materials. Often, these are manufactured with materials that transfer colour from the indicator to the occlusal surface contact area (Millstein & Maya, 2001).

1.2.3. Occlusal indicating materials

Clinicians require an accurate means of recording occlusal contacts (Millstein and Maya, 2001). There are several indicators available to aid the clinician in the refinement of the occlusion; Sharma et al. (2013) indicated that there are 17 that have been used (some of them no longer in use): 1) alginate impression material, 2) mylar paper strips, 3) polyether rubber impression bites, 4) silicone putty, 5) typewriter ribbon, 6) transparent acetate sheets, 7) wax, 8) wax articulation paper, 9) silk strips, 10) foils, 11) black silicone, 12) high spot indicator, 13) occlusal spray, 14) photo occlusion, 15) occlusal sonography, 16) T-Scan and 17) pressure sensitive films. These indicators vary in stiffness, thickness, design, colour and accuracy. The majority of these materials are used in conjunction with the very subjective patient "feel" feedback. The thickness of the materials may range from 0.002mm-0.109mm (Schelb et al., 1985). Thus the various materials may exhibit varying contact points due to thickness and resistance when placed interocclusally. To compound matters the restorative material being tested also plays a role in attaining clinically distinguishable occlusal contacts - gold, metal alloys, acrylic, ceramics and enamel all may vary the visibility of the indicator used. The material of choice as an occlusal indicating medium is yet to be standardized (Takai et al., 1993).

The most commonly used occlusal indicator is occlusal indicating (articulating) paper. It is popular due to its simplicity and low cost and it is not time-consuming. The colour of occlusal indicating paper may be blue, red, green and/or black. The description of occlusal paper by the manufacturers is not standardized and offers little information regarding its thickness and sensitivity, it is often described in terms of thin, micro thin, extra thin, extra-

extra thin, and thick (Schelb et al., 1985). This offers a relatively vague qualitative relationship to the true strip thickness or mark size.

A study conducted by Takai et al. (1993) evaluating three occlusal examination methods used to record contacts in lateral excursive movements in dentate subjects found that normal articulating paper can record contacts up to, but not exceeding 34 microns. This is in contrast to Schelb et al. (1985), who advocated that occlusal indicating strips should be less than 21µm. On the other hand black silicone is said to be a much more stable material and can record up to 100µm, therefore black silicone can record actual static contacts and 'near contacts' which may be in contact during normal occlusal function (Sharma et al., 2013). Polyether silicone impression bites are said to be the gold standard against which other indicators should be evaluated (Sharma et al., 2013). They exhibit good accuracy; however the method itself is not easy to use and is impractical in clinical practice. There is also strong evidence to suggest that silk strips are the best materials for indicating occlusal contacts (Sharma et al., 2013). It is manufactured from high quality natural silk of 80µm thickness. It has a high colour reservoir, is extremely tear resistant and flexible. It thus lends itself to adapt perfectly to cusps and fossae.

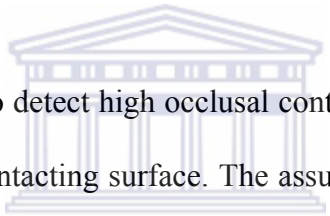
Mylar paper/shimstock films are made of metallic polyester film, which is 8µm thick, and when evaluated against articulating paper it has been found that they are a more reliable method (Sharma et al., 2013). Other novel occlusal indicating methods are sonography and T-Scan. Sonography first appeared in the dental literature in the 1960s. It detects tooth contact by the sound generated during mouth closure (Sharma et al., 2013). There is however a lack of data on the efficacy of this technique and the device used.

T-Scan is a computerised occlusal analysis system, it is designed to examine and record occlusal contact from a pressure sensitive film. The manufacturer reports that this system can digitally inscript both the location and timing of the contacts (Sharma et al., 2013). The

sensor is U-shaped and is 60µm thick and has 1500 sensitive receptor points. Several independent researchers have reported that the sensors do not have the same accuracy and they also always attain fewer contacts than the conventional method of articulating paper. The sensor has also been shown to be less accurate than silk ribbon (Sharma et al., 2013).

There appears to be no ideal occlusal indicating tool or material. It is thus imperative that clinicians understand the nature of the most commonly used material, its applications, analysis and shortcomings.

1.2.4. Articulating paper



Articulating paper is used to detect high occlusal contact. This is achieved through the dye leaving a mark(s) on the contacting surface. The assumptions made are (1) that the colour indicator is accurate and (2) that the observer/clinician interprets the markings made by the indicator material correctly.

The colour coating of the majority of occlusal indicating papers consists of waxes, oils and pigments. It comes in strips and also horse-shoe shaped sheets (Sharma et al., 2013). According to Millstein & Maya (2001) “occlusal contact might be present due to varying factors: there may be a meeting of two blunt surfaces or of the close contact of many irregular surfaces. Occlusal contacts may take place simultaneously or sequentially. “Near-contacts” are those that may appear to touch but do not. Surface friction may occur when two surfaces rub over each other. Furthermore articulating paper may be thin and smooth, and thus not engage the irregular topography in an occlusal surface. It may also be thick and coarse, and thus create friction and resistance on occlusal contact. It is such factors that may render the identification of “harmful” occlusal contacts difficult. Saliva may also ruin

articulating paper, it may be difficult to insert and seat due to the resiliency of the soft tissue beneath a lower complete denture, and they have a relatively inflexible base material; all these factors may result in an increased number of "pseudo" contact markings" (Saraçoglu & Özpinar, 2002). The advocated technique, in which the articulating paper is used, is to conduct the first test with the blue 200µm paper (Sharma et al., 2013). The "offending" surfaces will be immediately visible, as the pigments will be transferred from the paper to the high occlusal surfaces. The next step would then be to use a thin 8µm film with a different colour. The contrast between the two colours will clearly show high contacts and near contacts (Sharma et al. 2013).

1.2.5. Interpretation of occlusal markings

The interpretation of the contacts is critical in order to (1) avoid excessive occlusal adjustment by removing more denture tooth structure than required or (2) avoid missing interocclusal interferences by not discriminating between "true" and "pseudo" markings, giving a false sense of an appropriate distribution and number of contacts.

The interpretation of the articulating paper markings is a quantitative and qualitative process (Kerstein, 2008). It assesses the number, the distribution and intensity of contacts. The rationale is: large, dark marks are indicative of heavy occlusal loads; smaller, lighter marks indicate lesser loads. Lastly many similar sized marks on neighbouring teeth indicate equal occlusal contact intensity, evenness, and time simultaneity (Kerstein, 2008). Several scholars have questioned and criticized this descriptive analysis of occlusal contacts. In fact Millstein (2008) indicated that there are no American Dental Association (ADA) standards for the assessment of occlusal contacts and there are no scientific based guidelines for the clinician when utilising articulating paper. When grinding away the

offensive contacts, it is understood that it is the dark contacts that should be removed as these represent high contact areas. This interpretation of the contacts is in contrast with recent findings when using the T-Scan to evaluate the occlusal interferences (Kerstein, 2008). The dark heavily pigmented areas interpreted with the naked eye as high contacts have been shown not to be so. The size of the mark, whether large or small, donut-shaped or scratch like and whether light or dark in colour is not indicative of the magnitude of force in that area. Similar sized marks on neighbouring teeth have been found to exhibit varying forces; in fact similar marks within the same tooth could have different forces attributed to it (Kerstein, 2008).

1.2.6. Rater reliability in complete denture occlusion

The interpretation of occlusal contacts as described by Kerstein (2008) has however been clinically utilised for more than a century. It also continues to form part of undergraduate curricula in academic settings. There is still a lack of data on the intra-observer and inter-observer interpretation of the occlusal markings, amongst different observers. There are no studies evaluating the accuracy and interpretation of occlusal markings by observers when utilising the century-old but still popular articulating paper technique. Wilson and Rees (2006) found that significantly less occlusal markings were identified on dentures using a clinical remount technique compared to an intra-oral technique. Recently, a study by Geerts (2013) reported that rater-reliability was better when scoring occlusal marks on articulated dentures compared with scoring them on dentures when articulating paper was used intra-orally. Remount procedures were recommended for CD occlusal refinement over the intra-oral technique. Improved training of staff and students in reliably identifying true contacts was recommended.

1.3. AIM, OBJECTIVES AND HYPOTHESES

1.3.1. Aim

The aim of this study was to investigate the accuracy, intra- and inter-observer reliability of identifying occlusal markings made by articulating paper on complete dentures.

1.3.2. Objectives

1. Establish the accuracy of identification of the markings by groups of observers by comparing them with a control data set derived by consensus by 2 other observers
2. Establish intra-observer reliability by comparing the occlusal markings identified by the same observers at 2 different time intervals
3. Establish inter-observer reliability by comparing the occlusal markings identified by different groups of observers (students / dentists), and
4. Establish the role of the presence of the opposing denture on observer reliability and accuracy.

1.3.3. Null-hypotheses

1. The markings identified by different groups of observers do not differ from the control data set
2. There is no intra-observer reliability
3. There is no inter-observer reliability
4. Observer accuracy and reliability is not improved by the presence of the opposing upper denture.

CHAPTER 2: Research design and methodology

2.1. INTRODUCTION

The proposal was presented before the Research Committee of the Faculty of Dentistry and ethical clearance was obtained from Faculty and Senate Review Boards of the University of the Western Cape before embarking on the project.

All participants in the study signed an informed consent form (Appendix A).

2.2. RESEARCH DESIGN

This study is a controlled, randomized, cross-sectional study. Three groups of observers: third-year and fifth-year dental students as well as staff from the Department of Prosthetic Dentistry assessed the number and distribution of occlusal markings on two series of images of 14 lower CDs. The first group of images consisted of 14 lower dentures without the opposing upper denture (Figure 2.1). The second group of images consisted of the same 14 lower dentures, but this time the opposing upper denture was also shown (Figure 2.1). The three groups of observers assessed the two series of images twice, two weeks apart. This resulted in 12 databases of assessments collected over a period of at least eight weeks.

Before presenting the images to the observers, two examiners independently assessed the occlusal markings, noting the number and distribution of markings warranting adjustment. The examiners did this for both groups of images, only once. The examiners then compared each other's results and any disagreements on the occlusal markings were resolved by means of discussion until consensus was reached. The data obtained in this

way was used as a control to establish observer agreement of the markings made by the different groups of observers.

2.3. PREPARATION OF SAMPLES

During the delivery visit of CDs, pictures were taken of the occlusal surfaces with occlusal markings made by blue articulating paper (200µm Bauch®, Koln, Germany). The clinical procedure was performed by one clinician. The patient was guided into centric jaw relation, attempting to register the first point of contact. Anatomical denture teeth were used.

The images of both groups were captured into two separate Microsoft® PowerPoint files, and two separate Keynote files. The Microsoft® PowerPoint files were used to project the images to the student observers in a lecture hall, whilst the Keynote files were used on an iPad for academic staff observers. Figure 2.1. shows an example of the images for a mandibular denture with its corresponding maxillary denture.

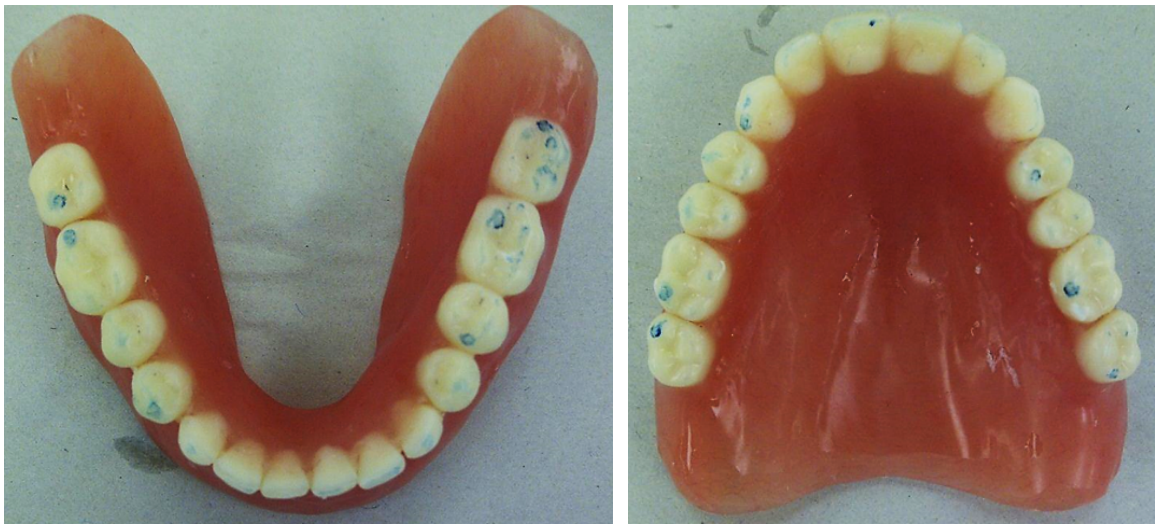


Figure 2.1: example of an image of a mandibular denture with its opposing maxillary denture.

2.4. DATA COLLECTION

Identical questionnaires (Appendix B) were drawn up and distributed among 10 clinical teaching staff with varying levels of experience, as well as to 10 students in the third and 10 students in the fifth year of their dental training programme. It was a convenience sample consisting of the first 10 volunteers agreeing to complete the full project (4 observations over at least eight weeks). The questionnaire was provided at the start of each assessment session for all observer groups. The original sequence of the images was noted and kept secret. Prior to each observation session, the images were randomised by means of an internet-based random sequencing program before each observer recording session.

The initial assessment for all observer groups was that of group 1 which comprised images of the 14 lower dentures alone. After two weeks, the observation was repeated for group 1. Another two weeks later, group 2, which comprised images of the same lower dentures with the opposing upper dentures adjacent to them, was assessed. And again, two weeks later, assessment of group 2 was repeated by all observer groups.

Data obtained was captured into a Microsoft® Excel spread sheet. A descriptive analysis was done, prior to statistical analysis.

For the control group, the influence of the presence of the upper denture was analysed by least squares regression analysis. Correctness of the different data series was done by comparing the mean scores of the different test data series with the control by means using analysis of variance. Intra-rater reliability was done by establishing the z-value for each observer within each series of data. Inter-rater reliability was established by comparing means of markings of the different observers in each group by means of analysis of variance.

CHAPTER 3: RESULTS

3.1. INTRODUCTION

There are 3 factors to be analysed:

1) 10 different observers (to determine inter-rater reliability)

2) 2 time intervals (to determine intra-rater reliability)

3) single lower denture as opposed to opposing denture also present (to determine the influence of the presence of the opposing denture).

3.2. CONTROL DATA SERIES

The scores for the control data series were achieved by means of consensus of two observers. This resulted in two data series, one for when the markings on the occlusal surfaces of lower dentures when assessed on their own, and one for when the markings on the lower denture when assessed together with the image of the opposing upper denture.

For the lower denture-only data series, the total number of occlusal markings on the 14 lower dentures was 56 (Table 3.2). The average number of markings for this group was 4.00 per denture. Sixteen markings were on the anterior teeth (average: 1.14), 40 on posterior teeth (average: 2.86).

For the complete denture-data series, the total number of occlusal markings on the 14 lower dentures was 53 (Table 3.3). The average number of markings for this group of dentures was 3.78. Eighteen markings were on anterior teeth (average: 1.28), 35 were on posterior teeth (average: 2.50).

Nine teeth on the database of the complete set had 1 marking more than the corresponding teeth on the single denture data series, 12 teeth on the complete set data series differed by 1 marking less than the single denture series.

Comparing the 14 dentures of the two data series, there were only 2 dentures (nos. 3 and 5) without any differences in markings, i.e. number and distribution were the same, regardless of the presence of the upper denture. There were 6 dentures with 1 difference in number of markings (nos. 2, 7, 8, 9, 11 and 12). There were 4 dentures with 2 differences in number of markings (nos. 4, 6, 10 and 13). There was 1 denture with 3 differences in number of markings (no.1). There was 1 denture with 4 differences in number of markings (no. 14).

Table 3.1

COMBINED SINGLE/SET

	Tooth 47		Tooth 46		Tooth 45		Tooth 44		Tooth 43		Tooth 42		Tooth 41		Tooth 31		Tooth 32		Tooth 33		Tooth 34		Tooth 35		Tooth 36		Tooth 37	
Denture	single	set	single	set	single	set	single	set	single	set	single	set	single	set	single	set	single	set	single	set	single	set	single	set	single	set	single	set
1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	2	1
2	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
4	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	2	1	0
5	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
6	0	0	1	0	1	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0
7	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
8	1	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0
9	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	2	2	0	0	0	0	2	1	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0
11	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0
12	0	0	1	1	1	1	1	1	0	0	0	0	0	0	1	1	0	0	0	0	1	1	1	0	0	0	0	0
13	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
14	1	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0

teeth with differences between 2 databases

teeth with the same markings on both databases

Table 3.1. Differences and similarities in distribution of the occlusal markings for the single lower denture and the complete set.

KEY: 0 = no markings
1 = one marking
2 = two markings

3.3. SUMMARY OF DATA FOR ALL GROUPS

Table 3.2 shows the average of the number of markings for each denture counted by the control and by the three test groups. For this table of values, the opposing denture was not present.

Table 3.2

denture	control	SINGLE DENTURE - FIRST READING			SINGLE DENTURE - SECOND READING		
		staff	BChDIII	BChDV	staff	BChDIII	BChDV
1	4	5.1	4.9	4.4	5.6	3.9	4.1
2	4	3.3	5.6	4.3	4.9	4.8	3
3	2	2.8	2.1	2.3	2.8	2.3	4.6
4	5	4	4.5	4.4	4.4	4.5	5.9
5	5	4	4.5	4	3.7	3.9	4.6
6	4	3.3	2.8	3.6	3.6	1.8	3.7
7	5	3.7	4.7	4.4	4.7	3.6	2
8	5	3.6	4.5	4.1	4.5	3.5	5.8
9	6	2.3	3.8	3.9	3	2.8	2.5
10	2	1.5	1.8	2.5	2.1	1.3	4.4
11	3	3.9	6.2	5.5	4.6	6	5.4
12	6	3.7	5.1	5.5	4.1	4.4	4.4
13	1	3	3.7	2.7	3.4	1.8	5.2
14	4	4.3	4.5	3.9	5.2	2.8	5.3
total	**56**	**48.5**	**58.7**	**55.5**	**56.6**	**47.4**	**60.9**
average	**4**	**3.5**	**4.2**	**4.0**	**4.0**	**3.4**	**4.4**

Table 3.2. Total and average of occlusal markings for control and all observer groups for the 14 single lower dentures.

Table 3.3 shows the same data when the opposing denture was present.

Table 3.3

denture	control	SET OF DENTURES - FIRST READING			SET OF DENTURES - SECOND READING		
		staff	BChDIII	BChDV	staff	BChDIII	BChDV
1	3	5.2	3.7	4.9	5.6	3.6	3.7
2	5	3.5	4.5	5.2	4.7	2.9	4.9
3	2	3	2.4	3	2.8	2.2	4.6
4	3	3.9	4.2	4	3.9	3.3	2.4
5	5	4.3	4.2	3.4	3.6	3.1	4.7
6	4	3.4	3.1	3.6	3.6	1.7	3.3
7	4	3.9	4.3	4.6	4.7	2.8	4.6
8	4	3.2	4.6	3.8	4.2	3	2.3
9	5	2.4	5.1	3.3	2.8	2.4	5.1
10	2	1.5	2.6	2.5	1.9	2.7	5.5
11	4	4.3	6.9	6	4.1	3.7	2.7
12	5	3.8	5.5	4.9	4.1	4	5.2
13	3	3.1	4.5	3.5	3.3	1.9	5
14	4	4.7	6.1	4.1	5	1.3	5
total	**53**	**50.2**	**61.8**	**56.8**	**54.3**	**38.6**	**59**
average	**3.8**	**3.6**	**4.4**	**4.1**	**3.9**	**2.8**	**4.2**

Table 3.3. Total and average of occlusal markings for control and all observer groups for the 14 complete sets of dentures.

3.4. STAFF DATA SERIES

Table 3.4 shows the number of occlusal markings counted by the staff members for the single denture. The highlighted cells show the highest and lowest means and totals.

Table 3.4												
SINGLE DENTURE - STAFF												
FIRST READING												
denture	**staff1**	**staff2**	**staff3**	**staff4**	**staff5**	**staff6**	**staff7**	**staff8**	**staff9**	**staff10**	**sum**	**average**
1	2	9	5	4	4	5	5	4	4	9	51	5.1
2	2	4	2	3	3	2	4	2	4	7	33	3.3
3	2	3	2	2	2	4	2	2	6	3	28	2.8
4	3	4	3	3	3	4	6	3	5	6	40	4
5	4	5	5	5	3	2	5	3	3	5	40	4
6	2	4	2	3	3	1	4	3	5	6	33	3.3
7	4	6	2	5	3	2	5	2	2	6	37	3.7
8	4	5	3	2	2	3	5	2	3	7	36	3.6
9	1	4	2	1	1	3	2	1	1	7	23	2.3
10	1	2	1	1	1	2	2	1	1	3	15	1.5
11	4	7	1	4	1	5	2	1	6	8	39	3.9
12	2	5	2	4	2	2	6	2	6	6	37	3.7
13	2	8	2	1	1	2	2	1	2	9	30	3
14	3	9	3	3	2	4	7	1	4	7	43	4.3
sum	**36**	**75**	**35**	**41**	**31**	**41**	**57**	**28**	**52**	**89**	**485**	**48.5**
average	**2.6**	**5.4**	**2.5**	**2.9**	**2.2**	**2.9**	**4.1**	**2.0**	**3.7**	**6.4**	**34.6**	**3.5**

Table 3.4. Sum and averages for the first reading by staff for the 14 single lower dentures.

A total of 485 occlusal markings for all dentures and all observers were counted. Staff member no.8 scored the lowest total number of occlusal markings for the 14 dentures, i.e. 28 with an average of 2.00 markings. Staff member no.10 scored the highest number of markings, i.e. 89 with an average of 6.36. No relationship could be established between these two staff members.

The lowest average of occlusal markings was for denture 10 (total of 15; average 1.5) and the highest average of occlusal markings was for denture 1 (total of 51; average 5.1). This does not agree with the control; they counted 2 markings for denture 10 and 4 markings for denture 1.

Table 3.5 shows the number of occlusal markings counted by the staff members for the single denture, when counted two weeks later.

Table 3.5												
SINGLE DENTURE - STAFF SECOND READING												
denture	**staff1**	**staff2**	**staff3**	**staff4**	**staff5**	**staff6**	**staff7**	**staff8**	**staff9**	**staff10**	**sum**	**average**
1	3	9	5	7	4	4	4	3	7	10	56	5.6
2	2	8	2	6	2	5	4	3	5	12	49	4.9
3	2	6	2	2	2	2	2	2	2	6	28	2.8
4	3	8	3	4	4	4	5	3	2	8	44	4.4
5	4	4	2	5	2	3	5	5	2	5	37	3.7
6	3	8	2	3	2	2	4	3	1	8	36	3.6
7	4	7	3	5	5	4	5	2	5	7	47	4.7
8	3	10	2	4	3	3	2	1	4	13	45	4.5
9	2	6	1	4	1	4	2	1	2	7	30	3
10	1	5	1	2	1	2	2	1	1	5	21	2.1
11	4	8	1	5	2	5	3	3	5	10	46	4.6
12	2	6	1	5	4	3	5	2	5	8	41	4.1
13	3	7	2	3	1	3	1	2	5	7	34	3.4
14	4	9	2	6	5	4	2	5	6	9	52	5.2
sum	**40**	**101**	**29**	**61**	**38**	**48**	**46**	**36**	**52**	**115**	**566**	**56.6**
average	**2.86**	**7.21**	**2.07**	**4.36**	**2.71**	**3.43**	**3.29**	**2.57**	**3.71**	**8.21**	**40.43**	**4.04**

Table 3.5. Sum and averages for the second reading by staff for the 14 single lower dentures. Highlighted cells show highest and lowest sum and average.

A total of 566 occlusal markings for all dentures and all observers were counted. This was higher than when the dentures were scored two weeks earlier. The lowest score was 29 (staff member no.3). The highest score was 115 (again for staff member no. 10).

Again, denture no.10 had the lowest score with only 21 markings as the total count from all observers. Also, again, the highest score was for denture 1 (56).

Table 3.6 shows the scores by staff for the lower dentures when evaluated together with the opposing denture. The total number of occlusal markings counted was 502. Staff member no. 5 counted the lowest total number of occlusal markings, i.e. 31 with an average of 2.21. The highest number of occlusal markings was, again, counted by staff no.10 with a total of 92, average 6.57.

Table 3.6

COMPLETE SET - STAFF

FIRST READING

denture	staff1	staff2	staff3	staff4	staff5	staff6	staff7	staff8	staff9	staff10	sum	average
1	4	9	5	4	4	4	5	3	4	10	52	5.2
2	2	4	2	3	3	3	4	3	4	7	35	3.5
3	2	3	2	2	2	2	2	2	6	7	30	3
4	4	4	3	3	3	2	6	3	5	6	39	3.9
5	3	5	5	5	3	4	5	5	3	5	43	4.3
6	2	4	2	3	3	3	4	3	5	5	34	3.4
7	4	6	2	5	3	3	5	2	2	7	39	3.9
8	3	5	3	2	2	3	5	1	3	5	32	3.2
9	2	5	2	1	1	3	2	1	1	6	24	2.4
10	1	2	1	1	1	2	2	1	1	3	15	1.5
11	4	7	1	4	1	6	2	3	6	9	43	4.3
12	2	5	2	4	2	3	6	2	6	6	38	3.8
13	2	8	2	1	1	2	2	2	2	9	31	3.1
14	3	9	3	3	2	4	7	5	4	7	47	4.7
sum	**38**	**76**	**35**	**41**	**31**	**44**	**57**	**36**	**52**	**92**	**502**	**50.2**
average	**2.71**	**5.43**	**2.50**	**2.93**	**2.21**	**3.14**	**4.07**	**2.57**	**3.71**	**6.57**	**35.86**	**3.50**

Table 3.6. Sum and averages for the first reading by staff for the 14 complete set of dentures. Highlighted cells show highest and lowest sum and average.

Table 3.7 shows the scores by staff when the lower dentures were scored together with the opposing denture two weeks later. The total number of occlusal markings counted was 543. This is higher than the first reading with the opposing denture present (502). Staff member no. 3 counted the lowest total number of occlusal markings, i.e. 29 with an average of 2.07. The highest number of occlusal markings was counted again by staff no.10 with a total of 106, average 7.57.

Table 3.7												
COMPLETE SET - STAFF												
SECOND READING												
denture	**staff1**	**staff2**	**staff3**	**staff4**	**staff5**	**staff6**	**staff7**	**staff8**	**staff9**	**staff10**	**sum**	**average**
1	4	8	5	8	4	3	4	3	6	11	56	5.6
2	3	8	2	6	2	5	4	3	5	9	47	4.7
3	2	6	2	2	2	2	2	2	2	6	28	2.8
4	4	5	3	4	4	4	5	3	2	5	39	3.9
5	3	4	2	5	2	3	5	5	2	5	36	3.6
6	3	8	2	3	2	2	4	3	1	8	36	3.6
7	4	7	3	5	5	4	5	2	5	7	47	4.7
8	3	7	2	4	3	3	2	1	4	13	42	4.2
9	2	6	1	3	1	4	2	1	2	6	28	2.8
10	1	5	1	2	1	2	2	1	1	3	19	1.9
11	2	7	1	5	2	5	3	1	5	10	41	4.1
12	2	6	1	5	4	3	5	2	5	8	41	4.1
13	2	7	2	3	1	3	1	2	5	7	33	3.3
14	5	9	2	6	4	3	2	5	6	8	50	5
sum	**40**	**93**	**29**	**61**	**37**	**46**	**46**	**34**	**51**	**106**	**543**	**54.3**
average	**2.86**	**6.64**	**2.07**	**4.36**	**2.64**	**3.29**	**3.29**	**2.43**	**3.64**	**7.57**	**38.79**	**3.88**

Table 3.7. Sum and averages for the second reading by staff for the 14 complete set of dentures. Highlighted cells show highest and lowest sum and average.

3.5. BChDIII STUDENT DATA SERIES

Table 3.8 shows the BChDIII students' first scores for the single denture. The total number of markings counted was 587. The highest score was for denture 11 (62), with an average of 6,2, the lowest score was for 10 (18), with an average of 1.8. The student who scored the highest was student 2 (85), with an average of 6.1, the lowest was student 10 (29), with an average of 2.1.

Table 3.8												
SINGLE DENTURE - BChDIII												
FIRST READING												
denture	**student 1**	**student 2**	**student 3**	**student 4**	**student 5**	**student 6**	**student 7**	**student 8**	**student 9**	**student 10**	**sum**	**average**
1	4	11	6	5	3	5	4	4	4	3	49	4.9
2	2	10	6	6	3	7	8	4	5	5	56	5.6
3	2	2	2	2	3	2	2	2	2	2	21	2.1
4	4	5	7	5	3	6	6	3	3	3	45	4.5
5	6	4	4	5	3	5	5	5	5	3	45	4.5
6	4	4	3	3	2	4	3	2	2	1	28	2.8
7	3	6	7	4	2	7	7	4	4	3	47	4.7
8	4	7	5	4	2	7	5	4	3	4	45	4.5
9	5	7	5	3	4	4	4	4	2	0	38	3.8
10	2	2	2	2	1	2	5	2	0	0	18	1.8
11	8	8	8	9	4	5	9	6	5	0	62	6.2
12	3	7	9	5	2	7	6	5	5	2	51	5.1
13	4	6	5	4	3	5	5	3	1	1	37	3.7
14	4	6	5	6	4	4	6	4	4	2	45	4.5
sum	**55**	**85**	**74**	**63**	**39**	**70**	**75**	**52**	**45**	**29**	**587**	**58.7**
total	**3.93**	**6.07**	**5.29**	**4.50**	**2.79**	**5.00**	**5.36**	**3.71**	**3.21**	**2.07**	**41.93**	**4.19**

Table 3.8. Sum and averages for the first reading by BChDIII students for the 14 single lower dentures. Highlighted cells show highest and lowest sum and average.

Table 3.9 shows the BChDIII students' scores two weeks later. A total reading of 474 was obtained. Denture 11 scored the highest (60). Denture 10 scored the lowest (13). Student 6 recorded the highest number of markings (91), with an average of 6,5. Student 3 scored the lowest (16), with an average of 1.1.

Table 3.9												
SINGLE DENTURE - BChDIII												
SECOND READING												
denture	**student 1**	**student 2**	**student 3**	**student 4**	**student 5**	**student 6**	**student 7**	**student 8**	**student 9**	**student 10**	**sum**	**average**
1	4	3	0	6	3	7	5	5	2	4	39	3.9
2	4	6	2	5	3	7	6	4	5	6	48	4.8
3	2	2	2	2	2	2	5	2	2	2	23	2.3
4	4	5	3	5	3	7	7	4	3	4	45	4.5
5	5	4	0	5	3	6	4	4	5	3	39	3.9
6	1	2	0	3	0	5	3	2	0	2	18	1.8
7	3	4	0	5	2	7	6	4	2	3	36	3.6
8	3	6	0	3	2	7	4	3	2	5	35	3.5
9	2	2	0	4	2	6	4	2	1	5	28	2.8
10	2	1	1	1	1	2	2	2	0	1	13	1.3
11	8	5	4	5	3	12	11	5	2	5	60	6
12	6	6	2	5	1	9	7	2	2	4	44	4.4
13	1	0	2	1	0	6	4	2	0	2	18	1.8
14	4	0	0	2	2	8	7	2	1	2	28	2.8
sum	**49**	**46**	**16**	**52**	**27**	**91**	**75**	**43**	**27**	**48**	**474**	**47.4**
average	**3.50**	**3.29**	**1.14**	**3.71**	**1.93**	**6.50**	**5.36**	**3.07**	**1.93**	**3.43**	**33.86**	**3.39**

Table 3.9. Sum and averages for the second reading by BChDIII students for the 14 single lower dentures. Highlighted cells show highest and lowest sum and average.

Table 3.10 shows the BChDIII students' first scores when the opposing denture was present. A total of 575 markings were recorded. Denture 11 had the highest total score (65). Denture 10 had the lowest (19). Student 6 sored the highest (85), with an average of 6.07 markings per denture. Student 10 scored the lowest (34) with an average of 2.4.

Table 3.10												
FULL SET - BChDIII												
FIRST READING												
Denture	**student 1**	**student 2**	**student 3**	**student 4**	**student 5**	**student 6**	**student 7**	**student 8**	**student 9**	**student 10**	**sum**	**average**
1	5	4	6	4	3	5	2	5	4	2	40	4.00
2	3	6	5	6	4	7	3	5	5	4	48	4.80
3	3	2	2	2	2	2	1	4	2	3	23	2.30
4	5	5	6	5	4	6	2	6	3	0	42	4.20
5	3	4	4	4	3	6	4	5	5	3	41	4.10
6	1	3	3	3	4	4	2	3	3	2	28	2.80
7	2	4	3	4	2	7	4	7	5	2	40	4.00
8	6	4	5	4	2	6	6	5	3	2	43	4.30
9	5	4	5	5	3	6	7	6	3	3	47	4.70
10	2	2	2	2	1	2	2	2	1	3	19	1.90
11	6	5	5	7	3	8	10	11	5	5	65	6.50
12	5	5	6	6	2	10	6	7	2	0	49	4.90
13	4	5	2	4	3	8	2	6	2	1	37	3.70
14	4	5	4	7	5	8	5	7	4	4	53	5.30
sum	**54**	**58**	**58**	**63**	**41**	**85**	**56**	**79**	**47**	**34**	**575**	**57.50**
average	**3.86**	**4.14**	**4.14**	**4.50**	**2.93**	**6.07**	**4.00**	**5.64**	**3.36**	**2.43**	**41.07**	**4.11**

Table 3.10. Sum and averages for the first reading by BChDIII students for the 14 complete sets of dentures. Highlighted cells show highest and lowest sum and average.

Table 3.11 shows the markings recorded for the BChDIII students evaluating the complete set two weeks later. The total was 386. This is considerably lower than that recorded at the previous assessment. Denture 12 scored the highest (40). Denture 14 scored the lowest (13). Student 6 scored the highest (77) with an average of 5.5 markings per denture. Student 5 and 9 scored the lowest (22) with an average of 1.57.

Table 3. 11												
FULL SET - BChDIII												
SECOND READING												
denture	**student 1**	**student 2**	**student 3**	**student 4**	**student 5**	**student 6**	**student 7**	**student 8**	**student 9**	**student 10**	**sum**	**average**
1	2	4	1	5	3	7	5	3	4	2	36	3.6
2	2	1	0	3	3	7	4	2	3	4	29	2.9
3	2	2	2	2	2	2	2	2	2	4	22	2.2
4	3	4	3	3	1	6	5	3	3	2	33	3.3
5	0	4	0	5	2	6	5	4	3	2	31	3.1
6	3	0	2	1	0	4	3	2	0	2	17	1.7
7	2	2	1	4	1	6	5	3	2	2	28	2.8
8	2	0	2	3	2	7	6	3	1	4	30	3
9	1	0	4	2	1	0	6	5	2	3	24	2.4
10	6	0	5	5	1	3	2	2	0	3	27	2.7
11	0	6	0	1	3	10	7	5	1	4	37	3.7
12	6	5	3	5	2	6	6	4	1	2	40	4
13	5	0	2	0	1	6	1	1	0	3	19	1.9
14	0	0	1	0	0	7	4	0	0	1	13	1.3
sum	**34**	**28**	**26**	**39**	**22**	**77**	**61**	**39**	**22**	**38**	**386**	**38.6**
average	**2.43**	**2.00**	**1.86**	**2.79**	**1.57**	**5.50**	**4.36**	**2.79**	**1.57**	**2.71**	**27.57**	**2.76**

Table 3.11. Sum and averages for the second reading by BChDIII students for the 14 complete sets of dentures. Highlighted cells show highest and lowest sum and average.

3.6. BChDV STUDENT DATA SERIES

Table 3.12 shows the BChDV students' first scores for the single denture. The total markings recorded were 555, which was less than that of the third-year group for the same assessment. The highest score was for dentures 11 and 12 (55). The denture with the lowest score was denture 3 with a score of 23. The student who scored the lowest was student 12 (29), with an average of 2.1 markings per denture, the highest was student 14 with a score of 83, with an average of 5.9.

Table 3.12												
SINGLE DENTURE - BChDV												
FIRST READING												
denture	**student 11**	**student 12**	**student 13**	**student 14**	**student 15**	**student 16**	**student 17**	**student 18**	**student 19**	**student 20**	**sum**	**average**
1	3	3	3	8	4	4	4	7	4	4	44	4.4
2	5	2	3	6	3	5	4	6	3	6	43	4.3
3	2	2	5	2	2	2	2	2	2	2	23	2.3
4	4	3	3	6	5	5	4	5	4	5	44	4.4
5	4	3	3	5	5	5	3	4	4	4	40	4
6	4	2	5	5	2	4	3	4	3	4	36	3.6
7	3	3	3	7	5	6	5	5	2	5	44	4.4
8	5	1	2	7	5	4	5	4	3	5	41	4.1
9	5	1	2	7	6	4	4	3	2	5	39	3.9
10	3	1	7	4	2	2	2	1	1	2	25	2.5
11	4	3	4	7	8	6	6	5	3	9	55	5.5
12	2	2	2	8	8	6	4	5	4	14	55	5.5
13	2	1	3	5	4	1	5	5	1	0	27	2.7
14	4	2	0	6	5	3	5	6	4	4	39	3.9
sum	**50**	**29**	**45**	**83**	**64**	**57**	**56**	**62**	**40**	**69**	**555**	**55.5**
average	**3.57**	**2.07**	**3.21**	**5.93**	**4.57**	**4.07**	**4.00**	**4.43**	**2.86**	**4.93**	**39.64**	**3.96**

Table 3.12. Sum and averages for the first reading by BChDV students for the 14 single lower dentures. Highlighted cells show highest and lowest sum and average.

Table 3.13 shows the markings recorded by the BChDV group 2 weeks later. The total score was 609. Denture 4 was the highest (59). Denture 7 was the lowest (20). Student 14 again scored the highest (100), with an average of 7.1. Student 12 again scored the lowest (38), with an average of 2.7.

Table 3.13												
SINGLE DENTURE - BChDV												
SECOND READING												
denture	**student11**	**student12**	**student13**	**student14**	**student15**	**student16**	**student17**	**student18**	**student19**	**student20**	**sum**	**average**
1	3	3	5	8	5	6	0	5	3	3	41	4.1
2	2	2	1	9	4	2	0	5	3	2	30	3
3	4	5	6	9	4	4	0	5	3	6	46	4.6
4	5	4	5	10	6	5	7	7	4	6	59	5.9
5	4	3	5	5	5	5	5	5	4	5	46	4.6
6	3	2	3	6	4	3	5	3	3	5	37	3.7
7	2	1	2	3	2	2	3	1	2	2	20	2
8	4	5	5	12	7	5	7	5	5	3	58	5.8
9	2	2	4	2	4	2	3	2	2	2	25	2.5
10	4	2	5	5	6	2	7	7	3	3	44	4.4
11	5	3	6	10	7	5	6	3	5	4	54	5.4
12	6	1	3	7	6	4	8	4	2	3	44	4.4
13	5	3	7	8	7	4	7	5	4	2	52	5.2
14	6	2	8	6	7	4	7	5	5	3	53	5.3
sum	**55**	**38**	**65**	**100**	**74**	**53**	**65**	**62**	**48**	**49**	**609**	**60.9**
average	**3.93**	**2.71**	**4.64**	**7.14**	**5.29**	**3.79**	**4.64**	**4.43**	**3.43**	**3.50**	**43.50**	**4.28**

Table 3.13. Sum and averages for the second reading by BChDV students for the 14 single lower dentures. Highlighted cells show highest and lowest sum and average.

In Table 3.14, the BChDV group evaluated the complete set for the first time and a total of 568 was recorded. Denture 11 scored the highest (60). Denture 10 scored the lowest (25).

Student 18 scored the highest (74), with an average of 5.3. Student 12 scored the lowest (44), with an average of 3.1.

Table 3.14												
FULL SET - BChDV												
FIRST READING												
denture	**student11**	**student12**	**student13**	**student14**	**student15**	**student16**	**student17**	**student18**	**student19**	**student20**	**sum**	**average**
1	5	4	2	7	5	4	6	7	3	6	49	4.9
2	5	4	9	4	6	4	5	5	4	6	52	5.2
3	2	4	7	2	3	2	3	2	2	3	30	3
4	3	4	3	4	5	4	3	5	4	5	40	4
5	0	3	2	4	4	4	4	5	3	5	34	3.4
6	4	2	5	4	4	4	3	3	3	4	36	3.6
7	3	4	4	5	5	6	5	5	4	5	46	4.6
8	4	3	5	3	3	5	5	3	3	4	38	3.8
9	5	2	3	5	4	3	3	2	2	4	33	3.3
10	2	1	1	2	2	2	1	9	1	4	25	2.5
11	9	4	6	7	8	6	8	3	7	2	60	6
12	5	3	5	4	6	5	5	9	4	3	49	4.9
13	2	1	1	4	5	1	5	10	3	3	35	3.5
14	4	5	0	6	3	5	5	6	2	5	41	4.1
sum	**53**	**44**	**53**	**61**	**63**	**55**	**61**	**74**	**45**	**59**	**568**	**56.8**
average	**3.79**	**3.14**	**3.79**	**4.36**	**4.50**	**3.93**	**4.36**	**5.29**	**3.21**	**4.21**	**40.57**	**4.06**

Table 3.14. Sum and averages for the first reading by BChDV students for the 14 complete sets of dentures. Highlighted cells show highest and lowest sum and average.

In Table 3.15, the BChDV group evaluated the complete set two weeks later and a total of 590 was obtained. Denture 10 scored the highest (55), denture 8 scored the lowest (23). Student 14 and 15 sored the highest (83), average 5.9, and student 12 scored the lowest (32), average 2.3.

Table 3.15												
FULL SET - BChDV												
SECOND READING												
denture	**student11**	**student12**	**student13**	**student14**	**student15**	**student16**	**student17**	**student18**	**student19**	**student20**	**sum**	**average**
1	5	2	4	3	5	4	6	3	3	2	37	3.7
2	5	3	5	7	5	5	5	6	4	4	49	4.9
3	4	4	5	6	8	3	4	5	3	4	46	4.6
4	2	1	1	7	5	1	3	1	2	1	24	2.4
5	5	2	5	5	6	5	5	5	4	5	47	4.7
6	3	2	3	5	4	3	5	3	3	2	33	3.3
7	5	2	6	8	7	3	5	3	4	3	46	4.6
8	2	2	3	2	4	2	2	2	2	2	23	2.3
9	4	3	6	7	7	6	6	5	4	3	51	5.1
10	8	3	3	8	8	4	7	6	4	4	55	5.5
11	2	1	9	3	3	2	2	1	2	2	27	2.7
12	2	2	5	7	8	4	10	5	6	3	52	5.2
13	4	2	8	8	6	3	7	7	3	2	50	5
14	5	3	3	7	7	4	7	5	5	4	50	5
sum	**56**	**32**	**66**	**83**	**83**	**49**	**74**	**57**	**49**	**41**	**590**	**59**
average	**4**	**2.29**	**4.71**	**5.93**	**5.93**	**3.50**	**5.29**	**4.07**	**3.50**	**2.93**	**42.14**	**4.21**

Table 3.15. Sum and averages for the second reading by BChDV students for the 14 complete sets of dentures. Highlighted cells show highest and lowest sum and average.

3.7. STATISTICAL ANALYSIS

3.7.1. Control data

The data of the control, for the single denture and the set, is the result of a single score reached by consensus of two observers.

The mean number of occlusal markings for the single denture was 4.000 per denture, and for the set was 3.786. The difference of the mean is -0.214. This is not significantly different from zero, suggesting that there is no difference between the single denture readings and the complete set readings.

However, earlier on, the descriptive statistics suggested that, even though the total number of markings may not be different, their distribution appeared to be (Table 3.1). Of the 14 dentures, there were only 2 dentures where the distribution of markings scored was exactly the same regardless of the presence of the opposing denture (dentures no. 3 and 5). Therefore, single-denture versus complete-set values were plotted, suggesting differences (Figure 3.1): the black line in the graph is one with intercept = 0 and slope = 1. Points should cluster around this line if there is no bias. However, the red line is the least squares regression line complete-set on single-denture, and it has slope = 0.500 with estimated standard error 0.138. Therefore, this slope differs significantly from slope 1. Note that (1-0.500)/0.138=3.62. What is indicated is that at low single total scores, the complete set total scores tend to be greater than the single total scores; at high single total scores, the set total scores tend to be smaller than the single total scores.

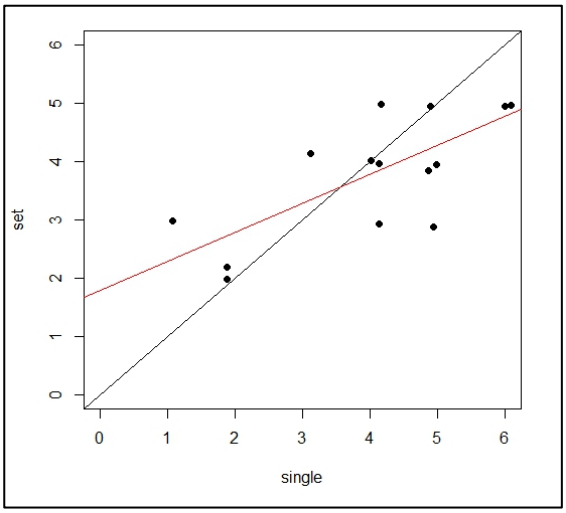


Figure 3.1: Plot of the control mean markings single-denture against complete-set.

3.7.2. Rater reliability for test groups

Intra-rater reliability

Tables 3.16 through 3.21 show information in terms of intra-rater reliability. In the last row of each table, the z-value = mean 1st reading – mean 2nd reading/S.E. 1st reading – 2nd reading. Where the absolute value of $z \geq 2$, statistically significant difference is indicated.

Inter-rater reliability

For the *inter-rater* reliability, two-way analysis of variance was performed. This is also indicated in Tables 3.16 through 3.21. This was done for both the first reading in the single and complete set, as well as for the second reading for the single and complete set.

ANOVA for the *first readings* of the single and complete set denture (first line of Tables 3.16-3.21) gave $F(9,117)=28.61$ and $P<0.001$. Any two means differing by 0.943 or more can be considered to differ significantly at level 0.05 or smaller.

ANOVA for the *second readings* of the single and complete set denture (second line of tables 3.16-3.21) gave F (9,117)=58.86 and P<0.001. Any two means differing by 0.916 or more can be taken to differ significantly at level 0.05 or smaller.

The error standard deviation (S.E.) of a total reading is estimated as 1.254. This is a pooled estimate over all staff and students.

3.7.3. Staff

Table 3.16 shows the *intra-rater* reliability for staff single lower denture. In the last row, the z values are highlighted for 3 observers (2, 4 and 10). The difference in their means of the 1st and 2nd readings are significantly higher than those of the other 7 staff members. This suggests that they are statistically significant.

Table 3.16

Single lower denture

Staff	1	2	3	4	5	6	7	8	9	10
mean 1st reading	2.571	5.357	2.500	2.929	2.214	2.929	4.071	2.000	3.714	6.357
mean 2nd reading	2.857	7.214	2.071	4.357	2.714	3.429	3.286	2.571	3.714	8.214
mean 1st - 2nd	-0.286	-1.857	0.429	-1.429	-0.500	-0.500	0.786	-0.571	0.000	-1.857
S.E. 1st – 2nd	0.163	0.533	0.251	0.327	0.327	0.327	0.408	0.359	0.655	0.533
z	-1.749	-3.484	1.710	-4.372	-1.528	-1.528	1.924	-1.593	0.000	-3.484

Table 3.16. The means of the first readings, second readings, the difference in the means, standard error and z-value for staff for the single denture. Blue highlights show inter-rater differences; yellow highlights show intra-rater differences.The green cells indicate no statistical difference from the control mean scores.

For the inter-rater reliability, Analysis of variance (ANOVA) was used. For the first readings of the single denture (first line of Table 3.16), the means of staff 2 and 10 are significantly higher than all other staff means.

For the second readings of the single denture (second line of Table 3.16) the means of the same staff members 2 and 10 are significantly higher than any other staff mean. Staff 3 and 4 also differ significantly from most other staff.

To determine intra-rater reliability for the complete set, the same is done as for the single set, as indicated in Table 3.17. This time, two staff members, 2 and 4, exhibit means that are significantly different. These two staff members also had statistically different scores when assessing the single denture (Table 3.16).

Table 3.17										
Complete set of dentures										
Staff	1	2	3	4	5	6	7	8	9	10
means 1st reading	2.714	5.429	2.500	2.929	2.214	3.143	4.071	2.571	3.714	6.571
means 2nd reading	2.857	6.643	2.071	4.357	2.643	3.286	3.286	2.429	3.643	7.571
means 1st – set 2nd	-0.143	-1.214	0.429	-1.429	-0.429	-0.143	0.786	0.143	0.071	-1.000
S.E. 1st -set 2nd	0.231	0.471	0.251	0.343	0.291	0.294	0.408	0.143	0.633	0.646
z	-0.618	-2.579	1.710	-4.163	-1.472	-0.486	1.924	1.000	0.113	-1.547

Table 3.17. The means of the first readings, second readings, the difference in the means, standard error and z-value for staff for the complete set. Blue highlights show inter-rater differences; yellow highlights show intra-rater differences. The green cells indicate no statistical difference from the control mean scores.

For the inter-rater reliability for the first reading (first line of Table 3.17), the mean scores of staff 2 and 10 differ from all other staff members, while the mean score of staff 5, 7 and 9 differ from most of the other staff members.

For the inter-rater reliability for the readings 2 weeks later (second line of Table 3.17), staff 2 and 10 differed from all other staff while staff 3 and 4 differed from most other man scores.

In summary, staff members 2, 4 and 10 showed the poorest inter and intra-rater reliability on both occasions.

For the single dentures, the mean control is 4.000 (Table 3.2). Based on an overall estimate of error variation the standard error of the difference between the control mean and any staff mean is 0.4866. Therefore, an observed difference of 0.954 or greater indicates statistical significance at level 0.05 or smaller. Except for staff members 7 and 9, the mean of all other staff members differed statistically from the control mean.

For the complete set, the mean control is 3.786 (Table 3.3). Based on an overall estimate of error variation the standard error of the difference between the control mean and any staff mean is 0.4620. Therefore, an observed difference of 0.906 or greater indicates statistical significance at level 0.05 or smaller. Except for staff members 4, 6, 7 and 9, the mean of all other staff members differed from the control mean.

Figure 3.2 is a plot of the mean single denture 1st reading (means s1), mean single denture 2nd reading (mean s2), mean complete set 1st reading (mean d1), and mean complete set 2nd reading (mean d2) versus years of experience of staff. There is no obvious association between years of experience and mean counts. In this analysis the staff individuals are treated as a random selection from a potential population of staff. There are four correlation coefficients:

mean s1 vs Years=0.095

mean s2 vs Years=-0.100

mean d1 vs Years=0.046

mean d2 vs Years=-0.090

These correlations are small and not statistically significant.

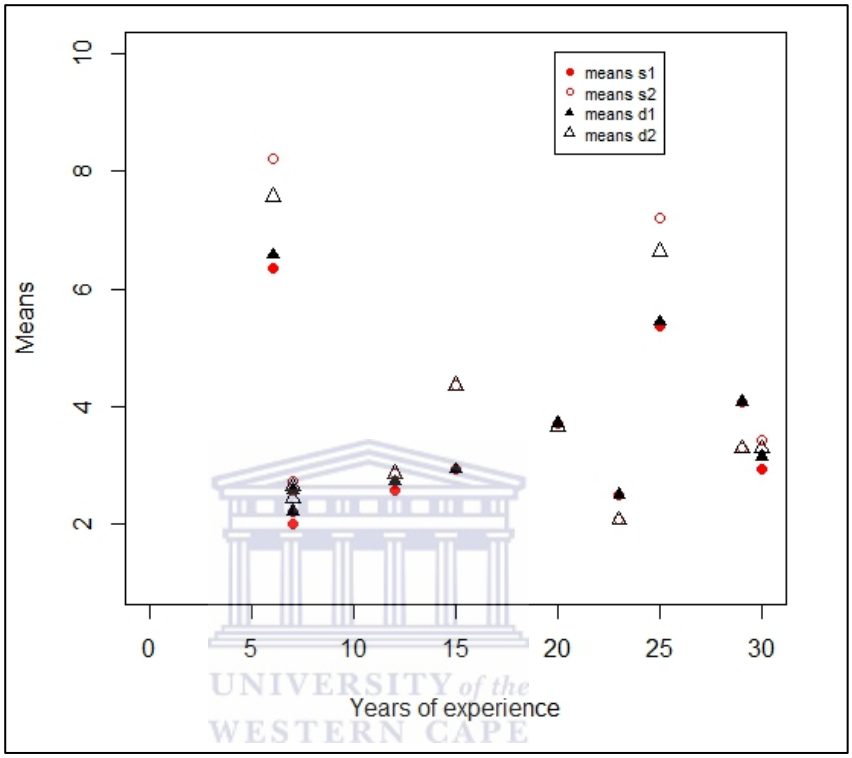


Figure 3.2: Plot of mean markings against years of experience.

3.7.4. Students

The results for the single denture and the BChDIII group are shown in Table 3.18.

Seven students (2, 3, 5, 6, 8, 9 and 10) show poor intra-rater reliability (yellow highlights).

Table 3.18										
Single denture										
Student BChDIII	1	2	3	4	5	6	7	8	9	10
means 1st reading	3.929	6.071	5.286	4.5	2.786	5	5.357	3.714	3.214	2.071
means 2nd reading	3.5	3.286	1.143	3.714	1.929	6.5	5.357	3.071	1.929	3.429
means 1st- 2nd	0.429	2.786	4.143	0.786	0.857	-1.5	0	0.643	1.286	-1.357
S.E. 1st – 2nd	0.465	0.697	0.533	0.459	0.275	0.522	0.432	0.308	0.322	0.44
z	0.921	3.998	7.772	1.712	3.122	-2.876	0	2.09	3.994	-3.085

Table 3.18. The means of the first readings, second readings, the difference in the means, standard error and z-value for BChDIII for the single denture. Blue highlights show inter-rater differences; yellow highlights show intra-rater differences. The green cells indicate no difference from the control mean scores.

Table 3.19										
Single denture										
Student BChDV	11	12	13	14	15	16	17	18	19	20
means 1st reading	3.571	2.071	3.214	5.929	4.571	4.071	4	4.429	2.857	4.929
means 2nd reading	3.929	2.714	4.643	7.143	5.286	3.786	4.643	4.429	3.429	3.5
means 1st – 2nd	-0.357	-0.643	-1.429	-1.214	-0.714	0.286	-0.643	0	-0.571	1.429
S.E. 1st – 2nd	0.551	0.414	0.724	0.878	0.549	0.539	0.76	0.663	0.359	0.998
z	-0.648	-1.552	-1.973	-1.383	-1.301	0.53	-0.845	0	-1.593	1.431

Table 3.19. The means of the first readings, second readings, the difference in the means, standard error and z-value for BChDV for the single denture. Blue highlights show inter-rater differences; yellow highlights show intra-rater differences. The green cells indicate no difference from the control mean scores.

Table 3.20										
Complete set										
Student BChDIII	1	2	3	4	5	6	7	8	9	10
means 1st reading	3.857	4.143	4.143	4.500	2.929	6.071	4.000	5.643	3.357	2.429
means 2nd reading	2.429	2.000	1.857	2.786	1.571	5.500	4.357	2.786	1.571	2.714
means 1st – 2nd	1.429	2.143	2.286	1.714	1.357	0.571	-0.357	2.857	1.786	-0.286
S.E. 1st – 2nd	0.747	0.582	0.615	0.737	0.440	0.590	0.427	0.543	0.366	0.384
z	1.914	3.680	3.716	2.326	3.085	0.968	-0.836	5.259	4.881	-0.744

Table 3.20. The means of the first readings, second readings, the difference in the means, standard error and z-value for BChDIII for the complete set. Blue highlights show inter-rater differences; yellow highlights show intra-rater differences. The green cells indicate no difference from the control mean scores.

Table 3.21										
Complete set										
Student BChDV	11	12	13	14	15	16	17	18	19	20
means 1st reading	3.786	3.143	3.786	4.357	4.500	3.929	4.357	5.286	3.214	4.214
means 2nd reading	4.000	2.286	4.714	5.929	5.929	3.500	5.286	4.071	3.500	2.929
means 1st – 2nd	-0.214	0.857	-0.929	-1.571	-1.429	0.429	-0.929	1.214	-0.286	1.286
S.E. 1st – 2nd	0.872	0.404	0.802	0.775	0.732	0.590	0.802	0.639	0.559	0.398
z	-0.246	2.121	-1.158	-2.027	-1.953	0.726	-1.158	1.900	-0.511	3.229

Table 3.21. The means of the first readings, second readings, the difference in the means, standard error and z-value for BChVI for the complete set. Blue highlights show inter-rater differences; yellow highlights show intra-rater differences. The green cells indicate no difference from the control mean scores.

Student readings compared with the control.

For the single denture, the mean control for the first reading is 4.000. Based on an overall estimate of error variation the standard error of the difference between the control mean and any student mean is 0.5306, so an observed difference of 1.040 or greater indicates statistical significance at level 0.05 or smaller.

For the single denture, two BChDIII students (1 and 4) did not differ from the control and showed good intra-rater reliability. (Table 3.18) Students 2, 6, 8, 9 and 10 showed some

similarity with the control score, but displayed poor reliability. Three students (3, 5 and 7) differed from the control and showed poor intra-rater reliability.

For the single denture and BChDV students (Table 3.19), all students displayed good intra-rater reliability. Six students (11, 13, 16, 17, 18 and 20) did not differ from the control. Students 15 and 19 had some similarity with the control scores. Students 12 and 14 differed completely from the control and did so consistently.

For the complete set the mean control for the first reading is 3.786. Based on an overall estimate of error variation the standard error of the difference between the control mean and any student mean is 0.5529, so an observed difference of 1.084 or greater indicates statistical significance at level 0.05 or smaller.

For the complete set (Table 3.20), only one BChDIII student (7) did not differ with the control and had good intra-rater reliability. Two students (1 and 10) had some similarity with the control and good intra-rater reliability. Five students (2, 3, 4, 5, and 9) showed some similarity with the control scores, but with poor intra-rater reliability. One student (6) differed completely with the control and consistently so. One student (8) differed from the control with poor intra-reliability.

For the BChDV students rating the complete set (Table 3.21), 4 students (11, 13, 16 and 19) did not differ from the control with good intra-rater reliability. Three students (15, 17, and 18) did have some similarity with the control scores, with good intra-rater reliability. Three students (12, 14 and 20) displayed some similarity but poor intra-rater reliability.

Considering all the 6 data bases represented by Tables 3.16 to 3.21, in only 17 instances (of the possible 60), did observers' mean scores not differ from the control mean scores with good intra-rater reliability. In all other 43 instances observers' mean scores differed from the control mean scores and/or displayed poor intra-rater reliability.

Differences between BChDIII and BChDV students.

Table 3.22 gives means of single denture 1st reading (s1), single denture 2nd reading (s2), complete set 1st reading (d1) and complete set 2nd reading (d2) for the two year groups. The last column gives the result of a t-test (unpaired) of significance of difference of the means. The means of the second readings of the complete set differ significantly between the 2 student groups. The others did not differ.

Table 3.22			
	BChDIII	BChDV	P
s1	4.193	3.964	0.673
s2	3.386	4.350	0.150
d1	4.107	4.057	0.904
d2	2.757	4.214	0.018*

*Table 3.22. BChDIII and V means. *=significant difference*

CHAPTER 4: DISCUSSION

4.1. Introduction

The objectives were to:

1. Establish the accuracy of identification of the markings by groups of observers by comparing them with a control data set derived by consensus by 2 other observers
2. Establish intra-observer reliability by comparing the occlusal markings identified by the same observers at 2 different time intervals
3. Establish inter-observer reliability by comparing the occlusal markings identified by different groups of observers (students / dentists), and
4. Establish the role of the presence of the opposing denture on observer reliability and accuracy.

Null-hypotheses

1. The markings identified by different groups of observers are not accurate
2. There is no intra-observer reliability
3. There is no inter-observer reliability
4. Observer accuracy and reliability is not improved by the presence of the opposing upper denture.

The answer to the null-hypotheses is as follows:

1. The majority of the mean scores of all the observes differed from the control mean score agreed by 2 other observers. Therefore, the first null-hypothesis is accepted
2. The second null-hypothesis is partially rejected because in 21 of the 60 instances, poor intra-rater reliability was found
3. The third hypothesis is accepted because poor inter-rater reliability was predominant in all data series
4. The fourth hypothesis is accepted because the presence of the opposing denture did not improve rater reliability.

4.2. Discussion of the results

Looking at the *control group*, the total number of markings counted for the 14 dentures was 56 (with an average of 4 markings per denture) for the single lower denture, and 53 (with an average of 3.78 markings per denture) for the denture with the opposing upper denture also available for assessment. Comparing these totals and means, there was no significant difference between the 2 series of dentures. At first glance, this means that for the control observers, it did not make a difference whether the upper denture was present or not when the markings were counted. However, looking at the distribution of the markings, there appeared to be a lack of correlation between the data series from single and full set markings. This became clear when a least squares analysis was done: while the total did not differ, different markings on teeth were identified and counted when looking at the lower denture with and without opposing upper denture. Therefore, it remains questionable if the presence of the opposing denture has an influence on the number of occlusal markings identified on a lower CD. This is clinically relevant because different

teeth may then be selected for occlusal adjustment in an effort to harmonize the occlusion. If the incorrect teeth are selected and adjusted, this may result in an occlusion that is not well-balanced. Shigli et al., (2008) stated that a well-balanced occlusion is one aspect of complete denture therapy that may contribute to patient adaptation.

When staff counted the markings on the lower dentures without the upper present, they counted 485 markings initially, and 566 two weeks later.

For the single denture, using the control scores agreed by 2 observers, staff 7 and 9 agree with the control scores, both also displaying good intra-rater reliability (z-value smaller than 2) (Table 3.16). Staff members 1, 3, 5, 6 and 8 differed from the control scores, but did so reliably (z-value smaller than 2). These staff members may be easier to train into discriminating between the correct markings as agreed by the 2 observers, and the incorrect occlusal markings compared to the following category of staff. Staff members 2, 4 and 10 also differed from the control, and displayed unreliability in scoring. These individuals may be the more difficult ones to standardize.

Still for the single denture, in terms of inter-rater reliability, an analysis of variance showed significant differences among staff members for both the first reading of the markings and the reading 2 weeks later. This means that staff are identifying different markings for occlusal adjustment when given the same dentures. This may have negative consequences for student training when staff do not agree on markings earmarked for occlusal adjustments.

For the complete set, the scores of staff members' nos. 4, 6, 7 and 9 did not differ from the control scores, with staff members 6, 7 and 9 displaying good intra-rater reliability also

(Table 3.17). Raters 1, 3, 5, 8 and 10 differed from the control readings, and did so reliably. Rater 2 differed from the control and also displayed poor intra-rater reliability.

It is important to remember in the interpretation of the results, that only mean scores were used to calculate z-values and compare means. However, when distribution was examined, more differences could be found among all raters. For example, staff member 9 showed no difference in the total and mean markings counted. However, when looking at the values for each denture, this staff member identified the same number of markings for 1 denture only (Tables 3.4 and 3.5). Therefore, it is appropriate to remember that results in this study may conceal differences in distribution that would make reliability scores worse than they appear.

To assess the extent of distribution differences, a least squares analysis similar to the one done for the control scores could be done for each observer. However, because substantial reliability differences were already found by using mean scores only, it was decided not to take the analysis further.

Looking at a possible association between years of experience of supervision staff and mean counts of markings, no correlation was found. It was thought that more experienced staff may correlate with the 2 control observers. This was not found.

The BChDIII group showed the highest prevalence of poor intra-rater reliability, with 13 out of 20 occurrences of z-value equal or higher than 2 (Tables 3.18 and 3.20). Inter-rater reliability was also poor with many significant differences between mean scores of observers. This poor reliability was to be expected as these students are treating edentulous patients with complete dentures for the first time.

The fact that these students do not correlate with the control, as well as the other staff observers, strengthens the argument that using articulating paper intra orally is in itself a flawed procedure and should not be done. This finding is consistant with that of Wilson and Rees (2006).

The BChDV group demonstrated the highest level of similarity with the control group with 28 of the 40 mean scores being similar to the control mean score. This was better than the staff. Staff only had 14 mean scores being the same as the control mean scores. The BChDV group also had the highest intra-rater reliability of all observer groups, with only 3 unreliable raters. Staff had 5 of those.

The large difference in reliability between the student groups, with the BChDV students performing so much better, may be attributed to coincidence. There is a general overall lack of correlation with all the observer groups, thus no other conclusion can be drawn from the findings of the BChDV group.

Very little literature exists in terms of exploring rater reliability when using articulating paper in removable prosthodontics. This makes it difficult to engage the results of this study with others. Wilson and Rees (2006) looked at occlusal markings when articulating paper was used on dentures intra-orally, or extra-orally on articulated dentures. It was found that the use of articulating paper on articulated dentures lead to fewer occlusal markings, more unilateral markings and improved rater reliability compared to using articulating paper on dentures in the mouth. The findings of my study seem to support these findings in the sense that the use of articulating paper intra-orally is unreliable.

This study supports the findings by Millstein (2008) indicating that there are no American Dental Association (ADA) standards for the assessment of occlusal contacts and there are no scientific based guidelines for the clinician when utilising articulating paper. Standardization guidelines are necessary to improve the clinician's ability to be consistent in identifying the correct markings. This is necessary because as highlighted by Wilson and Rees, (2006) "Despite the majority of prosthodontists recommending a remount procedure, the majority of dentists in general practice seem to prefer other quicker and more convenient methods."

It was assumed at the start of the study that the presence of the opposing denture, so that corresponding occlusal markings may confirm a true occlusal contact, may improve accuracy and intra-rater reliability. However, this proved not to be the case. Considering all observations, 30 correct mean scores were given for the single denture; 32 for the complete set. Also, 10 raters were unreliable when looking at the single denture only; 11 raters were unreliable when looking at the complete set.

4.3. Conclusions

Within the limitations of this study the following conclusions can be made:

1. All observer groups differed from each other
2. Intra-rater reliability was generally poor among all observers in the study.
3. Inter-rater reliability was poor for all the observer groups, for all observation periods.
4. The presence of an opposing denture did not to improve intra-rater reliability or accuracy.
5. There is no statistical significant correlation with years of experience in clinical practice and rater accuracy and reliability when assessing occlusal markings.
6. This study confirms that the use of articulating paper intra-orally to assess the occlusion in CDs is unreliable and invalid and should not be a clinical procedure.

4.4. Recommendations

Articulating paper should not be used intra orally to assess the occlusion in complete dentures.

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APPENDICES

APPENDIX A: Cover Letter

Restorative Dentistry

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South Africa

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Fax: +27 862746550

Email: sandilempungose@gmail.com

Information form

Dear colleagues / students

I, Sandile Mpungose, am a *Magister Chirurgiae Dentium* (MChD) student at the University of the Western Cape (UWC), student number: 2231806.

I am conducting a study with the title: "**Complete denture occlusion: an inter- and intra-observer analysis amongst different groups at a university setting".**

As the title explains, this study will look at the reliability among different groups of clinicians and students in the identification of articulating paper marks made on complete dentures. For this purpose, I need you to look at a series of 14 dentures and identify the markings made by articulating paper on denture teeth that you would consider for occlusal adjustment. This will have to be done on 4 occasions, each 2 weeks apart.

Your participation is voluntary and your identity will not be disclosed. The information supplied will remain confidential.

Your participation for the full duration of this study would be greatly appreciated. But, should you wish to withdraw your participation from this study, you can do so at any time without any negative consequences.

For further information, you can contact me at 0729176295 or sandilempungose@gmail.com.

If you choose to partake in this study, please sign the consent form.

Thank you for spending time in making this an effective study.

Kind Regards

Sandile Mpungose

Consent form

I, ……, agree to take part in the study with the title: "**Complete denture occlusion: an inter- and intra-observer analysis**" performed by Sandile Mpungose.

I have read and I understand the requirements and conditions of the study.

…… ……

Signature participant Date

…… ……

Signature researcher Date

APPENDIX B: QUESTIONNAIRE

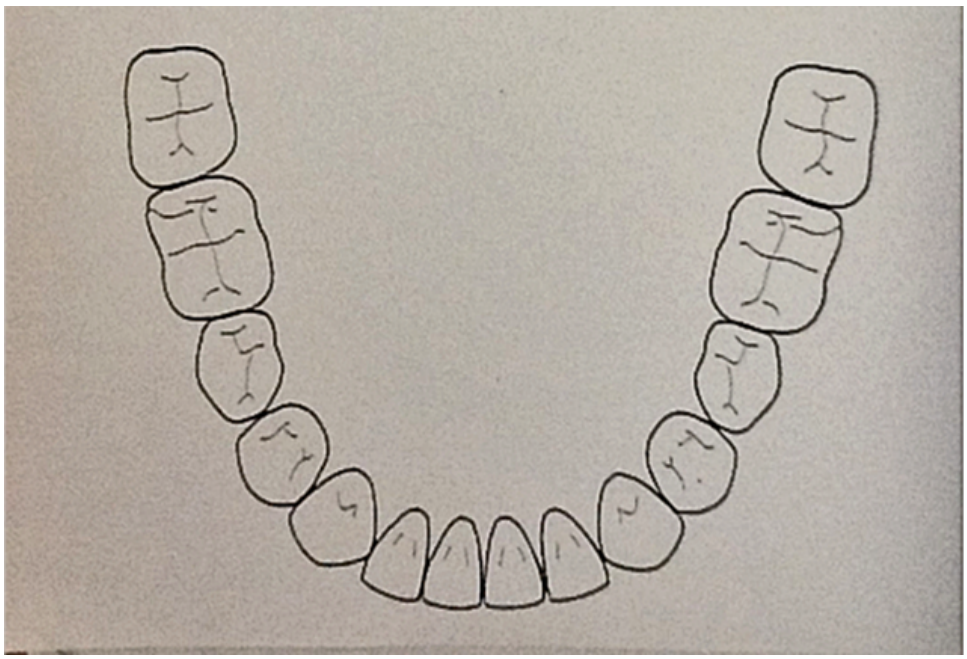
Staff No: ……

Research Questionnaire

1. Number of years in clinical practice : ……..… yrs
2. Do you work full-time or part-time as a clinician : …….-time
3. What percentage (%) of your time contributed to complete dentures?

Complete dentures	
Total	100%

4. Based on the markings made by articulating paper on the denture(s), draw on the diagram the markings you would grind in order to make the occlusion more even.
5. Please note that there could be more than one marking on a tooth.



Student No: …….

Research Questionnaire

1. Year of study: BChD ……
2. What percentage (%) of your time contributed to complete dentures?

Complete dentures	
Total	100%

3. Based on the markings made by articulating paper on the denture(s), draw on the diagram the markings you would grind in order to make the occlusion more even.
4. Please note that there could be more than one marking on a tooth.