Eur. J. Prosthodont. Rest. Dent., Vol.14, No. 2, pp 63-66
Printed in Great Britain

Abutment Taper of Full Cast Crown Preparations by Dental Students in the UWI School of Dentistry.

Reisha N Rafeek*, Shivaughn M Marchan†, Kevin G Seymour‡, Lifong F Zou§ and DYD Samarawickrama¶

Abstract - *Retention of crowns has been shown to be inversely proportional to taper. The objective of this study was to compare the abutment taper of teeth prepared for full veneer crowns by students at the UWI School of Dentistry with those of other dental schools. Twenty five dies were scanned by a Co-ordinate Measuring Machine (CMM) and the mean taper and standard deviations were found to be 20.3 ± 11.3 degrees mesio-distally and 18.3 ±8.5 degrees bucco-lingually. This study shows that the taper achieved by dental students at the UWI School of Dentistry preparing teeth for full veneer crowns is comparable to those achieved by other dental students in the US, UK, Europe and Japan.*

KEY WORDS: Taper, Co-ordinates, Metrology, Crowns, Teaching

INTRODUCTION

The University of the West Indies (UWI) School of Dentistry graduated its first cohort of dental students in 1994 and in 2000 introduced a new competency based curriculum. The Crown & Bridge course is taught in the new curriculum in the first semester of the fourth year. Dental students are taught full veneer crown preparations in this laboratory course using plastic typodont teeth set in a manikin phantom head. The retention of the full veneer crown depends on the length and diameter of the preparation as well as the degree of convergence occlusally of the axial walls. The angle formed between opposing walls of the preparation is called taper[1]. Retention of castings has been shown to be inversely proportional to taper angle[2]. The ideal taper recommended by Shillingburg et al [3] is 2-6 degrees and other schools also recommend similar angles [4,5].

Dental students have difficulty in seeing detail in laboratory demonstrations and in achieving correct taper during tooth preparation [4,6]. During the Crown & Bridge laboratory course they are given lectures, handouts and live demonstrations under a video camera with a magnified image on television monitors. This has been shown to improve performance during the teaching process [4].

It is difficult to transfer the skills learnt in the laboratory setting to the clinical situation and ideal taper is very difficult to achieve clinically[7,8]. Studies on tapers achieved by dental students have found mean tapers ranging from 12 – 27 degrees[5,6,7,8,9,10]. Studies on GDPs and specialists have found mean tapers of 20 degrees[11,12,13]. Tapers of up to 20 degrees have been shown to be clinically acceptable[10].

*BDS, MSc , FDSRCS
†DDS, MSc
‡BDS, MSc, PhD, DRD, MRD, MFGDP
§BSc, PhD
¶BDS, PhD, FDSRCS

Different methodologies have been employed to measure taper, including the use of dies and a microscope [9] shadowgraphs [6,10] and photocopying [5]. The current study utilises a technology commonly used in manufacturing industry and reverse engineering called co-ordinate metrology and more recently applied to human 'free-form' measurements. It characterises and defines the shape of geometric objects. The engineering machine has been adapted by software modification in order to analyse the human 'free-from' surfaces. Data acquisition is achieved by use of a probe, in this case an optical laser probe, as opposed to one with a stylus.

The preparation of a tooth for a full veneer crown is a common procedure in general dental practice and it is essential that dental students are competent in achieving acceptable abutment taper. It is necessary to investigate the outcomes of teaching in order to confirm that the students are on par with students of other dental schools in the reported literature, to examine competency of graduates, as well as to use as part of curriculum development and ongoing quality control [14]. The objective of this study is to examine the abutment taper of teeth prepared on patients for full veneer crowns by UWI dental students, achieved under clinical supervision and compare this with other dental schools.

MATERIALS AND METHODS

Dental students routinely provide a wide range of treatment for patients at the dental school Polyclinic as part of their training and all patients must initially be seen by two clinical instructors to approve the treatment plan. Once this has been done, treatment is carried out under the supervision of a clinical instructor, after obtaining the patient's consent at each visit. Approval was obtained for this study from the university research committee but no special instructions were given to either staff or students that would change from the routine clinical procedures

being performed. They were not aware that their preparation may be measured in this study.

Twenty five teeth that were prepared clinically by dental students for full veneer castings between January 2003 and April 2003 were included in the study. Figure 1 shows an example of a tooth prepared for a full veneer crown. Impressions were taken of the prepared teeth in an addition cured polyvinylsiloxane (PVS) impression material, Reprosil (Dentsply Caulk, Milford DE, USA). The impressions were approved by a clinical instructor as being acceptable to fabricate the casting. Figure 2 shows an example of an impression taken for a crown. The only change in routine was an instruction to the laboratory to pour up the impression twice instead of once. The impression first pour was used to fabricate the casting and a second pour was made for a sectional die. Dies made from the second pour of impressions are not as accurate as from the first pour but are still accurate enough to fabricate a casting. Also, addition cured PVS impressions have been found to demonstrate the least dimensional change between initial pour and second pour when compared to condensation cured PVS, polyether and polysulphide [15]. The die stone used was Vel-Mix Type IV stone (Kerr Corp., Orange CA, USA) and was mixed under vacuum and poured. Figure 3 shows an example of a die used to fabricate a crown showing bucco-lingual taper. After setting the dies were trimmed specifically with the standing base milled to be flat to the long axis of the prepared tooth. The sides were also milled so that the buccal and palatal were parallel to each other and the mesial and distal.

A pilot study showed that belle de St. Claire, Quick Set Die Spacer Blue (Kerr Corp., Orange CA, USA) was needed in order for the machine to effectively read the preparation. The die spacer was painted over the crown preparations at only the mid-bucco-lingual and mid-mesio-distal region with a band-width of approximately 2mm representing the width of the brush used to apply it. The effect of using die spacer is to seal any surface porosity on the die to overcome the incompatibility of the pink stone to the laser probe.

Figure 1. *A tooth prepared for a crown*

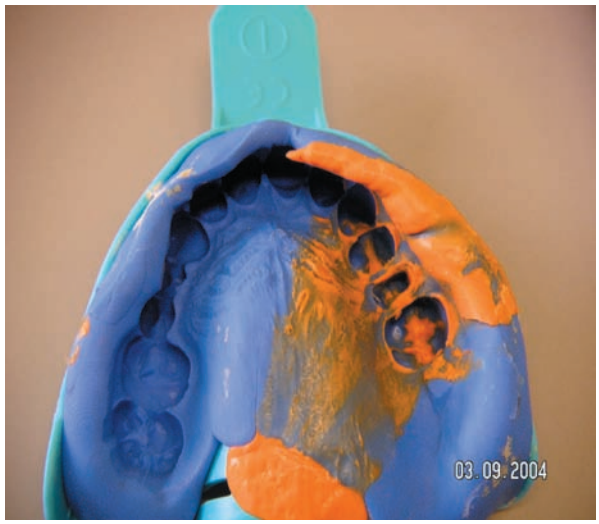

Figure 2. *An impression taken for fabrication of a crown*

Figure 3. *A die used to fabricate a crown*

To evaluate the degree of taper of the prepared tooth, the die stone was placed in a vice grip and scanned by specialised metrology equipment which consists of a Co-ordinate Measuring Machine (CMM) (Merlin II, Ferranti, UK), an optical probe (OP2), a rotatable probe head (PH9) (Reinshaw, UK), and a PC as a controller. This gave the exact taper of the preparation in a mesio-distal (M-D) plane and bucco-lingual (B-L) plane. 3-D co-ordinate metrology is an advanced measurement technology for free form surface measurements [16]. Such measurement consists of three separate processes: the 'extraction' of 3-D co-ordinates relating to the surface of the sample; the interpolation of these co-ordinate data into mathematical formulae in order for them to be transformed into a computer image; and thirdly image analysis - where linear, angular, or volumetric measurements are produced as required.

RESULTS

Table 1 shows the results for the twenty-five (25) clinical specimens in both mesio-distal (M-D) and bucco-lingual (B-L) planes. Twelve per cent (12%) of specimens showed an undercut in the M-D or B-L plane and the mean taper and S.D of the remaining specimens were 20.3 degrees (SD=11.3) mesio-distally and 18.3 degrees (SD=8.5) bucco-lingually. Excluding the teeth that were undercut, the taper ranged from 4 degrees to 38 degrees mesio-distally and from 7 degrees to 37 degrees bucco-lingually.

DISCUSSION

Dentistry is a skill-based discipline and therefore the quality of the work achieved is dependant on the level of the skill of the dentist. The level of skill achieved is largely a function of the training received during the undergraduate programme and any further postgraduate programmes attended. This training is related to the ability of the teachers to impart the skill-based techniques. The skills training in itself is by necessity subjective, for example "eyeballing" a crown preparation and determining whether the taper is "adequate" or "too much". Clearly there is a need to bring measurement to dentistry and this more formal dimensional assessment of crown preparations will assist in the feedback to and training of dentists.

The metrology equipment used in this study has been extensively used in the engineering and manufacturing fields but its use is fairly new in a dental setting. It has been used previously to measure the width of the crown preparation margin and the angulation of the margin [16,17]. There are no reports in the literature for its use in the measurement of taper and this is a highly accurate and reproducible method. Although the ideal taper has been suggested to be between 2-6 degrees, it has been recommended that a taper of 16 degrees may be more realistic [3]. Students have difficulty in transferring skills from the laboratory setting to the clinical and Weed [6] has found that students could only produce 22.8 degrees of taper clinically as compared to 12.7 degrees taper produced on typodonts in the laboratory. The use of visual aids has been shown to improve students performance during the teaching process [4]. Perhaps the availability of simple scanning equipment in the pre-clinical laboratory setting which would allow for immediate measurement of the preparation taper and subsequent feedback to the student would improve skills training and enhance student performance.

Table 1. Taper of the specimens in mesio-distal (M-D) and bucco-lingual (B-L) planes.

SPECIMEN	Mesio-distal (M-D) taper (°)	Bucco-lingual (B-L) taper (°)
1	30	28
2	4	8
3	0	-9
4	-10	7
5	9	32
6	-2	7
7	38	21
8	19	14
9	25	11
10	22	18
11	32	9
12	19	12
13	20	-6
14	32	24
15	13	21
16	30	16
17	18	12
18	29	27
19	5	15
20	-5	-15
21	23	23
22	10	28
23	38	13
24	5	19
25	26	37

The results of this study conducted in the UWI School of Dentistry found tapers of 20.3 degrees mesio-distally and 18.3 degrees bucco-lingually. This is similar to a study conducted in a US dental school that found the mean abutment taper from dies of crown preparations undertaken by dental students to be 19.3 degrees mesio-distally and 20.1 degrees bucco-lingually [5]. Another study on final year students in a dental school in Europe found mean abutment tapers of 12.8 degrees mesio- distally and 22.5 degrees bucco-lingually [9]. Mack, obtained 25 clinical specimens each from five dental schools in the UK and reported an average of 16.3 degrees for abutment taper. More recently, another UK study compared 4th and 5th year undergraduate students, clinical teaching staff and general dental practitioners (GDPs). The mean tapers found for 4th year students were 27 degrees mesio-distally and 24 degrees bucco-lingually and for 5th years 16 degrees mesio-distally and 15 degrees bucco-lingually. The clinical staff achieved mean tapers of 17 degrees for both M-D and B-L sections and the GDPs achieved approximately 15 degrees for both sections [8]. Final year dental students in a Japanese dental school were found to have prepared teeth with a mean abutment taper of 19 degrees and this was determined to be clinically acceptable as there was seldom any dislodgement of crowns [10].

A recent laboratory study has shown that even if the preparation is "over tapered" at 24 degrees but the crown is cemented with an adhesive resin cement, the retention value was 20% higher than the retention of a crown cemented with a conventional cement on a preparation of 6 degrees taper [18]. This suggests that adhesive cements can compensate for tapers that are above the ideal range of 2-6 degrees and the concern of over tapering the preparation becomes less critical.

These studies all employed a different methodology to the one used in this study so some caution should be applied when making comparisons, however the values obtained for abutment taper in this study fall within the range reported in the literature obtained by other dental schools. This augurs well for the UWI School of Dentistry as it is necessary to ensure that the teaching is producing dental graduates who are on par with other longer established schools in terms of clinical competence.

CONCLUSION

This study shows that the taper achieved by dental students at the UWI School of Dentistry preparing teeth for full veneer crowns is comparable to those achieved by other dental students in the US, UK, Europe and Japan.

MANUFACTURERS' DETAILS

- Reprosil (Dentsply Caulk, Milford DE, USA)
- Vel-Mix Type IV stone (Kerr Corp., Orange CA, USA)
- belle de St. Claire, Quick Set Die Spacer Blue (Kerr Corp., Orange CA, USA)
- Co-ordinate Measuring Machine (CMM) (Merlin II, Ferranti, UK),
- optical probe (OP2), (Reinshaw, UK),
- rotatable probe head (PH9), (Reinshaw, UK)

ADDRESS FOR CORRESPONDENCE

Dr. Reisha Rafeek, Lecturer in Restorative Dentistry, School of Dentistry, Faculty of Medical Sciences, The University of the West Indies, Mount Hope, Trinidad & Tobago. Email:reisha@trinidad.net

REFERENCES

1. Rosenstiel E. The taper of inlay and crown preparations. *Br Dent J* 1975; **139**: 436-8
2. Jorgensen KD. The relationship between retention and convergence angle in cemented veneer crowns. *Acta Odontol Scand* 1955;**13**: 35-40
3. Shillingburg H, Hobo S, Whitsett LD, Jacobi R, Brackett SE. Fundamentals of fixed prosthodontics. 1997. Chicago; Quintessence.
4. Robinson PB and Lee JW. The use of real time video magnification for the pre-clinical teaching of crown preparations. *Br Dent J* 2001; **190** (9):506-10.
5. Noonan JE and Goldfogel MH. Convergence of axial walls of full veneer crown preparations in a dental school environment. *J Prostbet Dent* 1991; **66**:706-8
6. Weed RM, Suddick RP, Kleffner JH. Taper of clinical and typodont crowns prepared by dental students. (Abstract) *J Dent Res* 1984; **63**:286.
7. Mack PJ. A theoretical and clinical investigation into the taper achieved on crown and inlay peparations *J Oral Rehabil* 1980; **7**: 255-65.
8. Patel PB, Wildgoose DG, Winstanley RB. Comparison of convergence angles achieved in posterior teeth prepared for full veneer crowns. *Eur J Prosthodont Rest Dent* 2005;**13:** 100-104.
9. Ohm H and Silness J. The convergence angle in teeth prepared for artificial crowns. *J Oral Rehabil* 1978; **5**: 371-5.
10. Sato T, Mutawa N, Okada D and Hasegawa S. A clinical study on abutment taper and height of full cast crown preparations. *J Med Dent Sci* 1998; **45** : 205-210.
11. Nordlander J, Weir D, Stoffer W, et al. The taper of clinical preparations for fixed prosthodontics. *J Prostbet Dent* 1988; **60**:148-51.
12. Eames WB, O'Neal SJ, Monteiro J, Miller C, Roan JD, Cohen KS. Techniques to improve the seating of castings. *J Am Dent Assoc* 1978; **96**:432-7.
13. Kent WA, Shillingburg HT, Duncason MG: Taper of clinical preparations for cast restorations. *Quintessence Int* 1988: **19**:339-345.
14. Rafeek RN, Marchan SM, Naidu RS, Carrotte PV. Perceived competency at graduation among dental alumni of the University of the West Indies. *J Dent Educ* 2004; **68:** 81-88.
15. Johnson GH, Craig RG. Accuracy of four types of rubber impression materials compared with time of pour and a repeat pour of models. *J Prostbet Dent* 1985; **53:** 484-490.
16. Seymour KG, Zou LF, Samarawickrama DYD, Lynch E. Assessment of shoulder dimensions and angles of porcelain bonded to metal crown preparations. *J. Prostbet. Dent.* 1996. **75**: 406 - 411.
17. Cherukara GP, Seymour KG, Samarawickrama DYD, Zou LF. A study into the variations in the labial reduction of teeth prepared to receive porcelain veneers – a comparison of three clinical techniques. *Br. Dent. J.* 2002. **192**: 401 – 404.
18. Zidan O, Ferguson GC. The retention of complete crowns prepared with three different tapers and luted with four different cements. *J Prostbet Dent* 2003; **89**: 565-571.