Modern Parameters for Crown Fabrication: Clinically Acceptable?

Part I: Assessing the Marginal Contour of Milled Restorations

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Background/Problem

When a crown is made using a completely digital (aka "model-less") workflow, the laboratory technician is left without a physical point of reference. Crowns fabricated via this modality rely solely on the intra-oral scan for design and fabrication. This may ultimately result in more work for the clinician. Without a working die, fine adjustments of fit and contour which were formerly completed in the laboratory, can now only be completed intraorally at the time of delivery.

A variety of digitally designed, milled restorations were fabricated for the clinics at the University of Tennessee and found to be below clinical standards due to problems with marginal contour and retention and resistance. This prompted questions regarding manufacturing, fit, and the potential for optimization.

Discussions with a local laboratory owner provided some enlightenment. He explained that milled crowns are often digitally designed with deliberately overbulked margins. Unsintered zirconia and unfired lithium disilicate are relatively fragile; thicker margins prevent chipping during milling, which yields fewer re-mills.

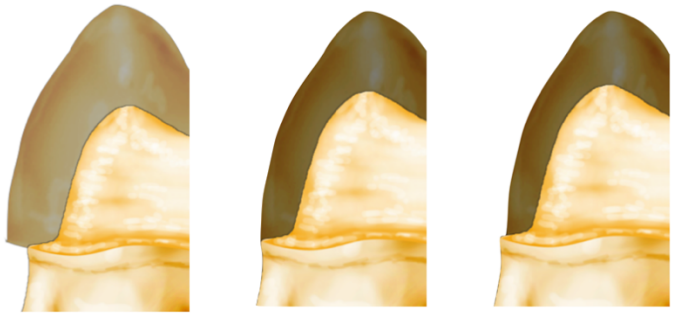
Focus Questions

The clinical observations and discussion with the laboratory owner were the impetus for this project. A small pilot study was designed to evaluate the fit and contour of milled restorations. Part I of this study involved evaluation of crown margins.

The focus of the work centered around the following questions:

1) Can fabrication methods be manipulated to idealize the marginal contour?
2) How will clinicians rate those modified marginal contours in terms of clinical acceptability?

FIGURE 1. ***Marginal Contour***



Long/ Overbulked ***Flush*** ***Short***

What Does "Marginal Contour" Mean?

For the purposes of this study, marginal contour refers to the extent that the external surface of a restoration is smooth and continuous with the external surface of the remaining tooth structure. "Flush" represents the clinically acceptable ideal.

Experimental Design

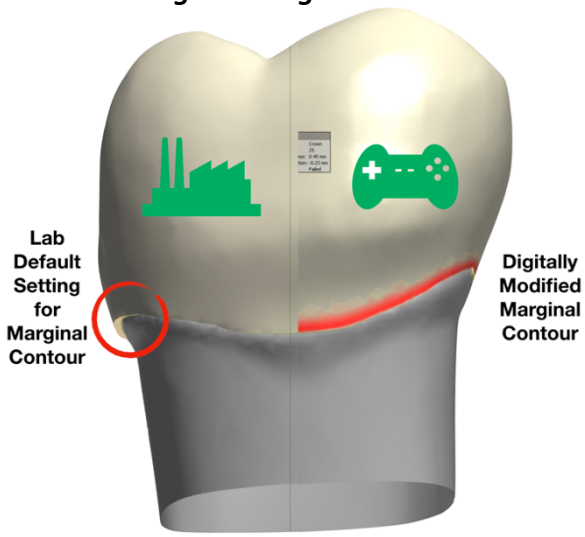
A series of crowns were made using both analogue (wax pattern and pressing of a lithium disilicate ingot) and digital workflows (computer-aided design and milling of lithium disilicate and zirconia crowns); see Figure 2. The crown margins were selectively modified to idealize contour, either by 1) slimming the margin in the digital design prior to milling or 2) hand-finishing the margin back to a stone working die after milling was complete.

Experimental Design (Continued)

The crown samples were randomized after they were fabricated, and 15 clinicians from the University of Tennessee completed a blinded survey (attached) to evaluate the crowns based on fit, contour, and overall clinical acceptability.

FIGURE 2. ***Study Samples***

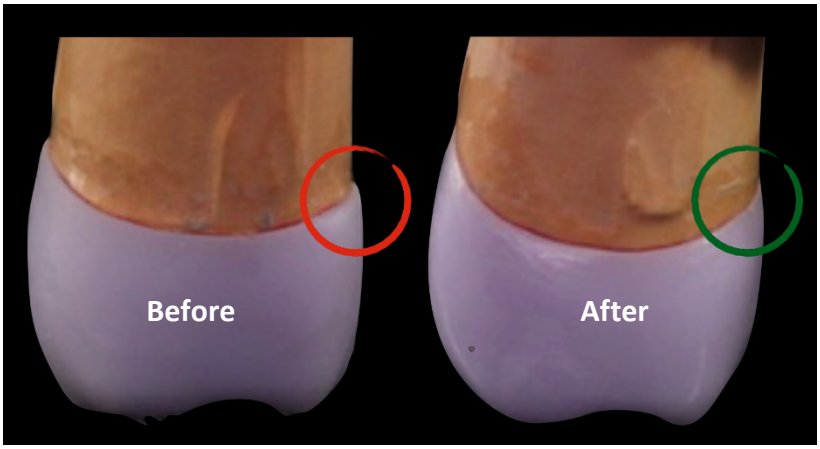
FIGURE 3. ***Digital Design***



Digitally Designed Crown Margins

Digital design software includes the ability to designate a series of default settings for the multitude of parameters that can be controlled during restoration design. These defaults are typically set by the laboratory. The left side of the digital "wax-up" in Figure 3 depicts the margin contour when default settings are applied. However, it is possible to customize and/or alter specific parameters to idealize contour and fit *prior* to milling. This is depicted on the right side of the digital "wax-up" in Figure 3. From the perspective of the design screen, it appears as though the long margin on the left is effectively resolved on the right. Part of this study included an evaluation of whether these modifications yielded clinically appreciable differences.

FIGURE 4. ***Hand-Finishing After Milling***



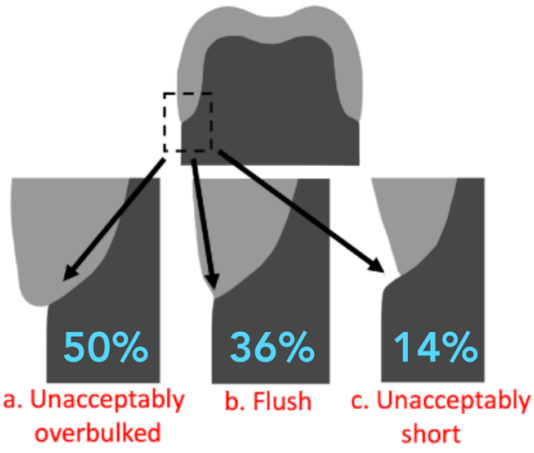
Hand-Finishing After Milling

An additional set of study samples were made using a stone die to finish back milled crown margins made from default design settings. This study sought to evaluate: 1) whether or not clinicians could differentiate the finished and "unfinished" crowns, and 2) how this affects clinical acceptability.

Survey Results

Pressed Lithium Disilicate

2. Which option best describes the marginal contour of this crown? Please circle response.

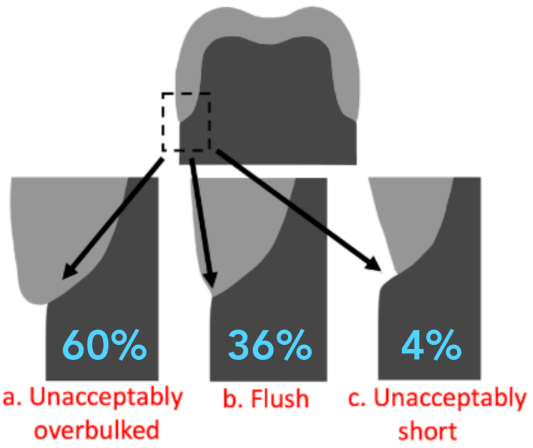


Based on the prompts of the survey (Question 5), 79% of respondents would NOT deliver these crowns, 21% would.

Milled LiSi & Zirconia, DEFAULT Marginal Milling Parameters

**Figures are averages of LiSi and Zir Data*

2. Which option best describes the marginal contour of this crown? Please circle response.

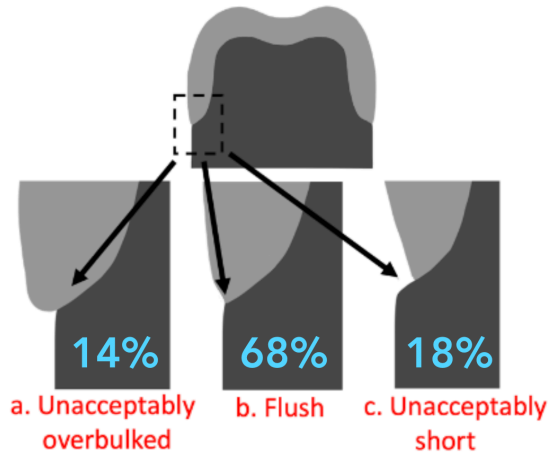


Based on the prompts of the survey (Question 5), 67% of respondents would NOT deliver these crowns. 33% would.

Milled LiSi & Zirconia, MODIFIED Marginal Milling Parameters

**Figures are averages of LiSi and Zir Data*

2. Which option best describes the marginal contour of this crown? Please circle response.

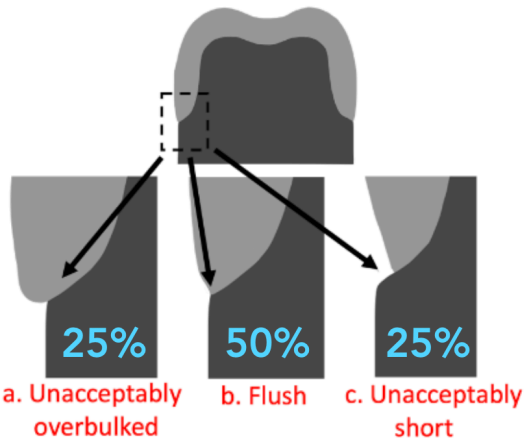


Based on the prompts of the survey (Question 5), 40% of respondents would NOT deliver these crowns, 60% would.

Milled LiSi & Zirconia, HAND-FINISHED After Milling

**Figures are averages of LiSi and Zir Data*

2. Which option best describes the marginal contour of this crown? Please circle response.



Based on the prompts of the survey (Question 5), 53% of respondents would NOT deliver these crowns, 47% would.

Discussion

The results indicated that when margin contours were refined either by hand-finishing after milling or by digitally modifying the margin design prior to milling, clinicians tended to rate these margins as being flush more frequently than they did for the pressed and default-setting milled crowns. It is difficult to make firm conclusions from this data for a variety of reasons. It is important to be aware that this project was only a pilot study, and the results were garnered from the feedback of 14 clinicians evaluating a pool of 36 crowns. These data were also not statistically analyzed and reflect only what percentage of respondents gave any particular response.

Additionally, conclusions which may be drawn from the data about clinicians' approval for cementation are confounded by the fact that respondents were driven to answer this question considering the four parameters that the survey highlights. A majority of respondents may have found crown margin contours to be clinically acceptable on a particular sample type, yet still rejected the crown for cementation due to other parameters of resistance and retention which were not adequate. Therefore, it is not possible to say that the improved marginal contour led to increased clinical acceptability; the cause for acceptance or rejection of a crown was multi-factorial.

A large number of the milled lithium disilicate crowns returned from the milling center with chipping at the margins before any type of handling or firing took place. Some 55% of the lithium disilicate crowns displayed this issue (Figure 5). All three variations of milled lithium disilicate crowns (Milled Default,Milled with Modified Settings, Hand-finished) returned with at least 1 crown (and as many as 4) displaying some chipping around the margin. This is particularly concerning in milling centers where production is strictly digital, and there is no way to inspect a crown on a die to determine how this chipping may alter, fit, contour, or marginal seal. In the purely digital workflow, the only way to evaluate a crown is by trying the restoration in the patient's mouth and waiting until the day of delivery to find that the restoration is or isn't clinically acceptable.

Conclusions

The basic trends of this preliminary survey would suggest that there are viable ways to improve crown contour before and after milling. A milled crown, being made in an entirely different workflow than that of traditional cast gold or stacked ceramic, presents new and different challenges for fit. It is important for clinicians to be aware of these differences and to have an idea of lab processes. In this way, they can better communicate with laboratories to improve the restorations they produce and fabricate crowns which fit the patient, not the needs of assembly line productivity.

FIGURE 5. ***Marginal Chipping During Milling***

Reference

- Parameters of Care for the Specialty of Prosthodontics. J Prosthodont 2020 Jul;29(S1):3-147.

Acknowledgements

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  - Dr. Scott Hollis-Assistant Director
  - Dr. Angi Gullard-Director of Research
  - Ms. Cindy Deaton, CDT

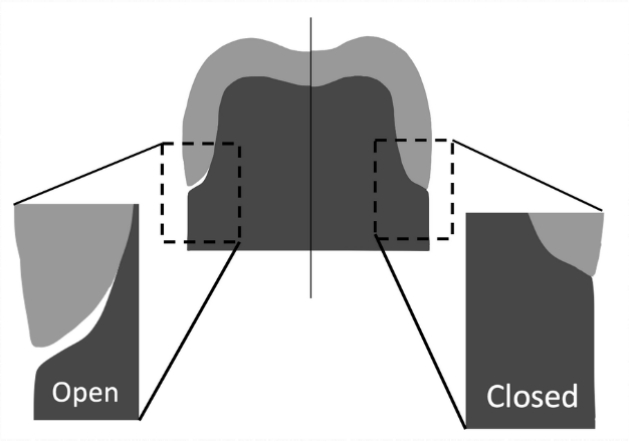
sample preparation will receive the cemented crown. Diagrams are provided to clarify the questions. Thank you for your help with this project!

Sample #:_____

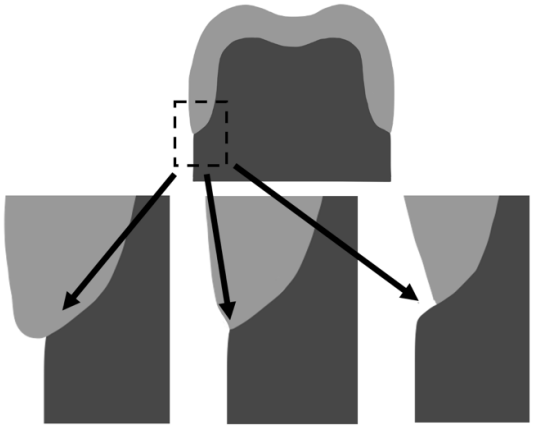
SURVEY

1. Is there a clinically unacceptable marginal gap (an open margin)?

Yes_____ No_____



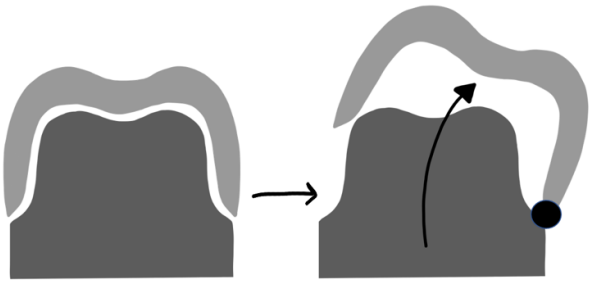
2. Which option best describes the marginal contour of this crown? Please circle response.



a. Unacceptably overbulked b. Flush c. Unacceptably short

3. Can this crown rotate in a clinically unacceptable way around a horizontal axis as shown in this diagram?

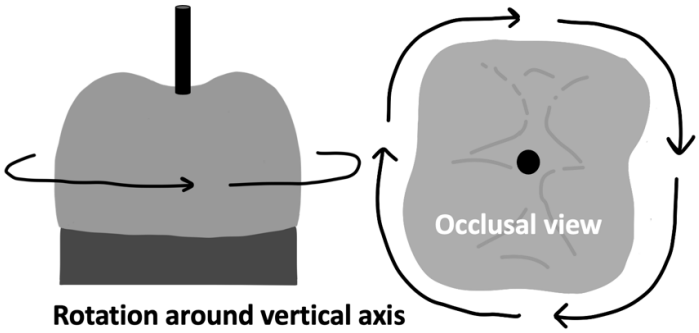
Yes_____ No_____



Rotation around horizontal axis

4. Can this crown rotate in a clinically unacceptable way around the vertical axis As shown in this diagram?

Yes_____ No_____



Rotation around vertical axis

5. Given the four conditions in the above questions, would you deliver this crown?

Yes_____ No_____

6. Do you feel that an explorer was needed for this evaluation?

Yes_____ No_____