Modern Parameters for Crown Fabrication…Clinically Acceptable?
Part II: Assessing the Mechanical Retention and Marginal Fit of Milled Restorations

International Academy of Gnathology Congress XXX
Seattle, Washington
August 2022

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Introduction:

With increasing application of computer aided design and manufacturing (CAD/CAM) in prosthodontics and restorative dentistry, long held laboratory criteria for restoration fabrication are being adapted to increase useful application of the technology for both laboratory technicians and clinicians. Design software incorporates restoration milling parameters that are specified by both the laboratory and the material manufacturers. Among these parameters are those designating the amount of cement gap space. Cement gap settings are among several settings that may have significant implications for restoration fit and stability, and these have been a subject of interest since the advent of CAD/CAM dentistry. Taking clinical advantage of these milling parameters and understanding their limitations, to improve treatment outcomes, is an important tool for the knowledgeable clinician.

Objectives:

1. Inform clinicians about design parameters used in the fabrication of milled crowns.
2. Evaluate the mechanical retention and marginal fit of milled crowns from a clinician's viewpoint.
3. Identify whether alteration of cement space milling parameters impacts clinical opinion of restoration retention and fit.

Rationale:

Studies indicate that increasing the cement gap space in CAD/CAM processes results in improved margin closure. Conversely, increasing the cement gap space can also result in reduced mechanical retention and decreased rotational stability of restorations on prepared teeth or implant abutments.[1] Some providers accept reduced mechanical retention, relying instead on bonding potential and favorable resin cement mechanical properties. However, when the cement gap space is increased above a threshold value, loss of rotational stability results in potential for incorrectly seating the crown and this has been shown to increase the marginal gap.[1] In 3Shape Design

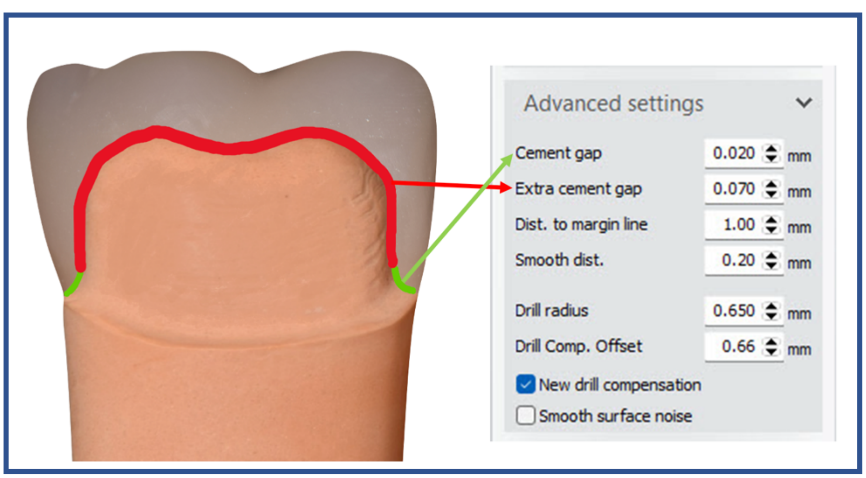

Figure 1: Design Software Cement Space Settings

software, the cement gap space settings are designated for the portion of the preparation closest to the finish line (typically a lower number, designated as "cement gap") as depicted by the green line in Figure 1. The designated space around the remainder of the preparation is designated in 3Shape software as "extra cement gap" space. Thus, two parameter settings are used to designate the desired cement gap space in CAD/CAM crown production. Traditionally, cement gap spaces have been achieved by layering die spacer on physical casts, with an "ideal" thickness range corresponding to the ADA specified cement film thickness from 25-40 mm.[2,3] Digitally designed cement spaces in many laboratories may be more than double this dimension (up to 45/90 mm default setting for some laboratories).

Ranges of cement gap settings used in previously published studies vary from 20/30 μm up to 100 μm or more.[4,1,5,6,7] Universal recommendations from manufacturers or labs could not be identified, possibly because of additional variables such as mill functionality and mill upkeep. Previous studies have evaluated the impact of cement space thickness on marginal gaps, mechanical retention, etc. using quantitative measurement (e.g. absolute marginal discrepancy) or 'pull-off' tests.[6,8,9] However, translating in vitro research to clinically meaningful outcomes is challenging. The intent of this project is to evaluate variability in cement gap settings in terms of crown fit and mechanical stability in the opinion of blinded evaluators.

Experimental Design:

In order to complete this study, groups of traditionally pressed lithium disilicate, milled lithium disilicate and millled zirconia were fabricated to fit the same idealized molar crown preparation. Based on cement gap settings used in previous studies and default milling parameters for several local laboratories, it was concluded that a reasonable lower limit would be as follows: a cement gap setting of around 20 μm for the cement gap near the margin and 60 μm for the cement gap on the remaining portion of the preparation. Likewise, we determined that a reasonably excessive setting would be 45 μm cement gap near the margin and 90 μm on the remainder of the preparation. For the milled lithium disilicate and zirconia, groups were fabricated using these lower limit cement gap settings higher limit cement gap settings in 3Shape design software. The crown designs were randomized and sent to the laboratory for milling over several days with coded names so that the milling center would not know how the settings had been altered for each of the crowns. The resulting crowns were assigned in random order to blinded reviewers comprised of prosthodontists and restorative dentists. Reviewers completed a survey for each of the crowns, including questions about the marginal integrity (Figure 2) and vertical and horizontal rotational stability (Figures 3 and 4). Lastly, reviewers disclosed whether they felt the crowns were acceptable for delivery in their own practice (Figure 5).

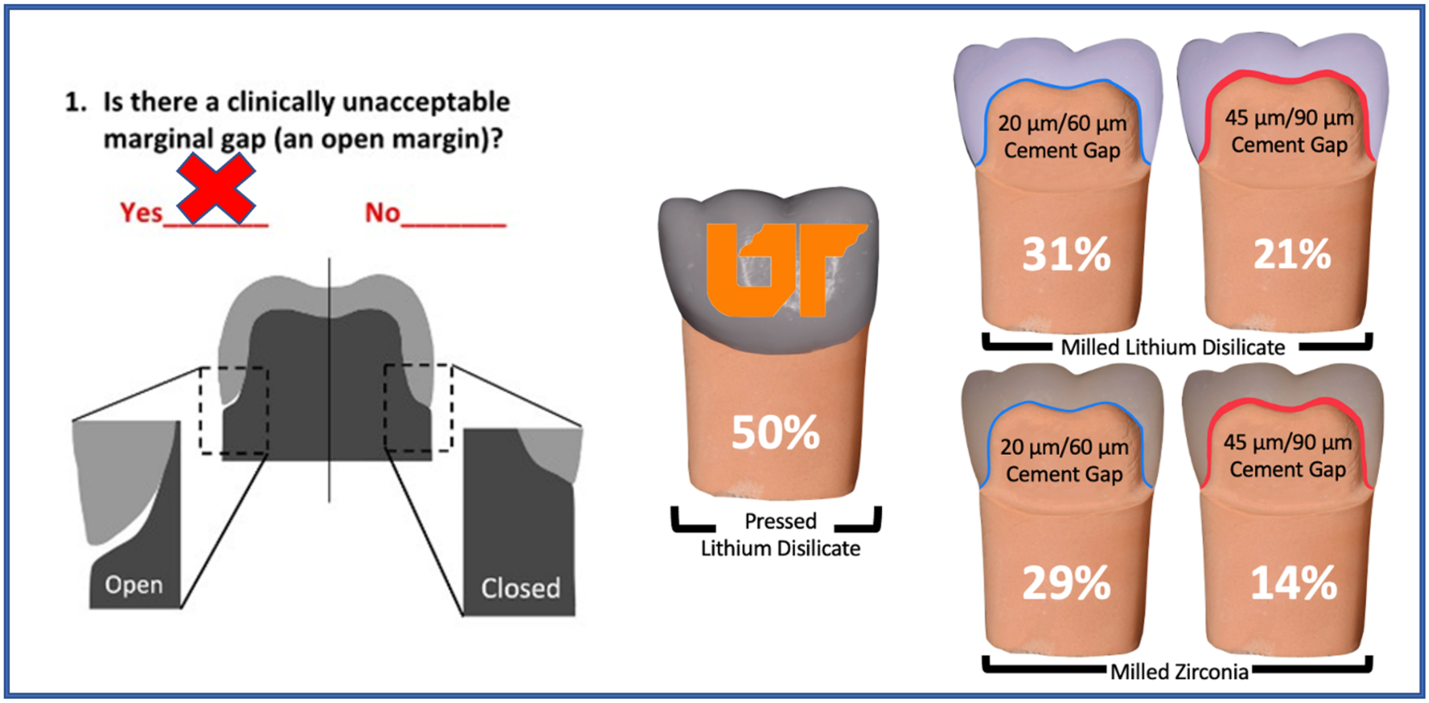

Figure 2: Assessment of Clinically Noticeable Marginal Gap

Results:

Survey responses were given by 14 clinicians without knowledge of what parameters were changed or what material was used for each crown. Roughly 1/3 of survey respondents elected to wear loupes while completing the survey. Of the milled restorations, approximately 10% more were identified as having an open margin if a smaller cement gap setting had been used. Around 30% of the milled lithium disilicate or zirconia crowns were judged to have open margins. Over half of the milled lithium disilicate crowns were returned from the lab in the blue stated (pre-firing) with chipping damage to the margins, and the presence of noticeable chips may have increased the percent reported as having open margins. Some of the zirconia crowns with decreased cement gap settings were determined to have open margins along with a very tight fit, such that adjustment at delivery would have been required in order for the crown to fully seat (Figure 6). The crowns with increased cement gap settings were felt to have poorer rotational stability than those crowns with lower cement gap settings, supporting quantitative in vitro data that has been reported in the literature previously. Lithium disilicate groups (including the control, pressed Emax) were found to have poor rotational stability around a vertical axis for 40-50% of the crowns in each group (Figure 4). Several of the crowns with increased cement gap settings were noted to have enough rotational instability that finding the appropriate position to fully seat the crown required some effort (Fig 6).

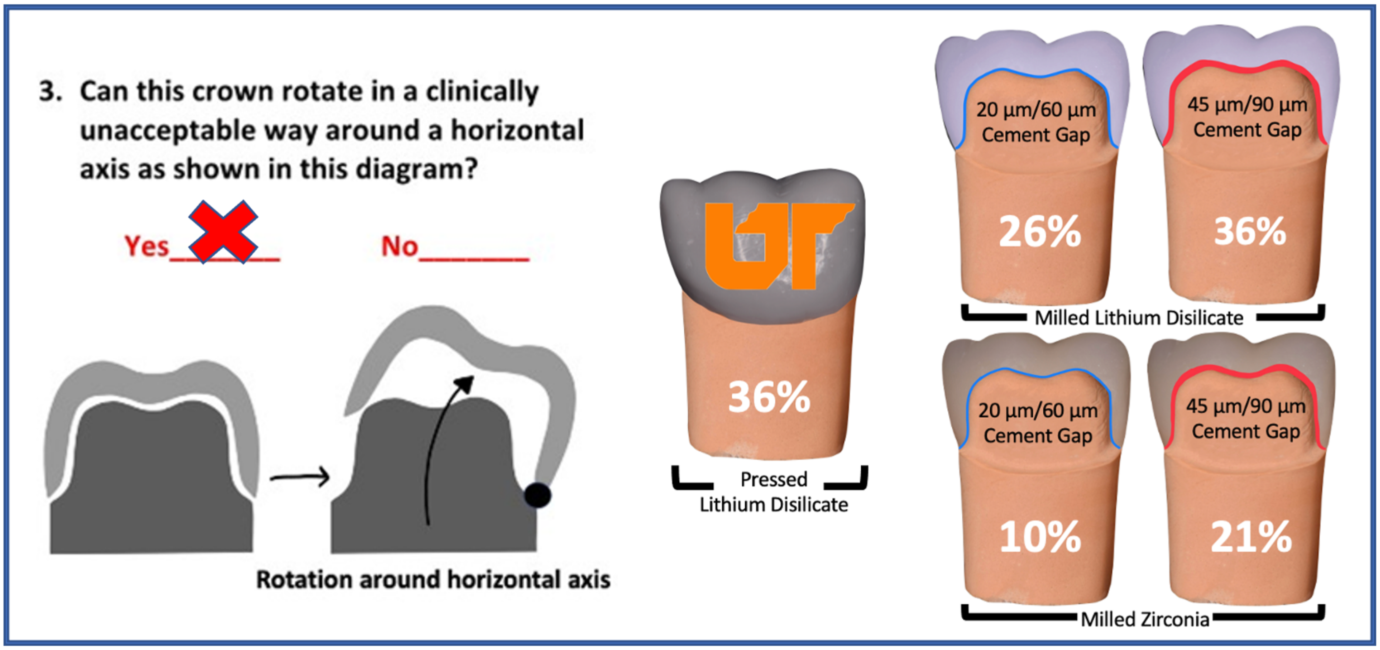

Figure 3: Rotational Instability Around a Horizontal Axis

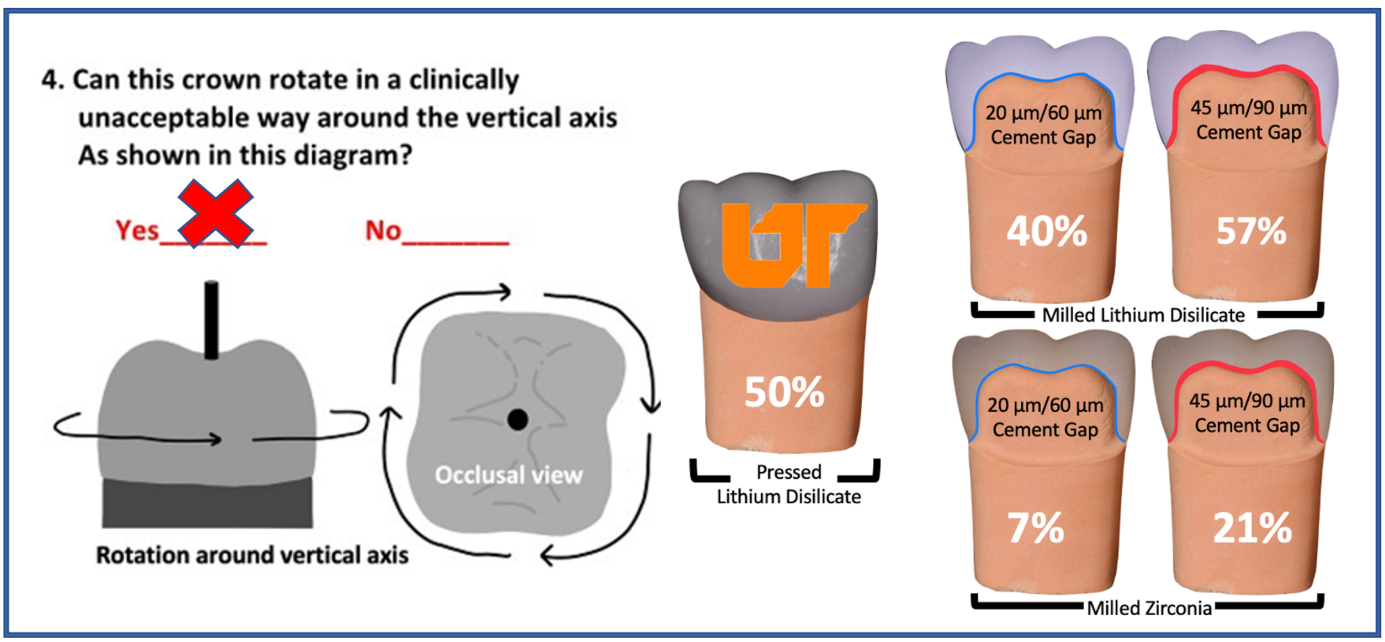

Figure 4: Rotational Instability Around a Vertical Axis

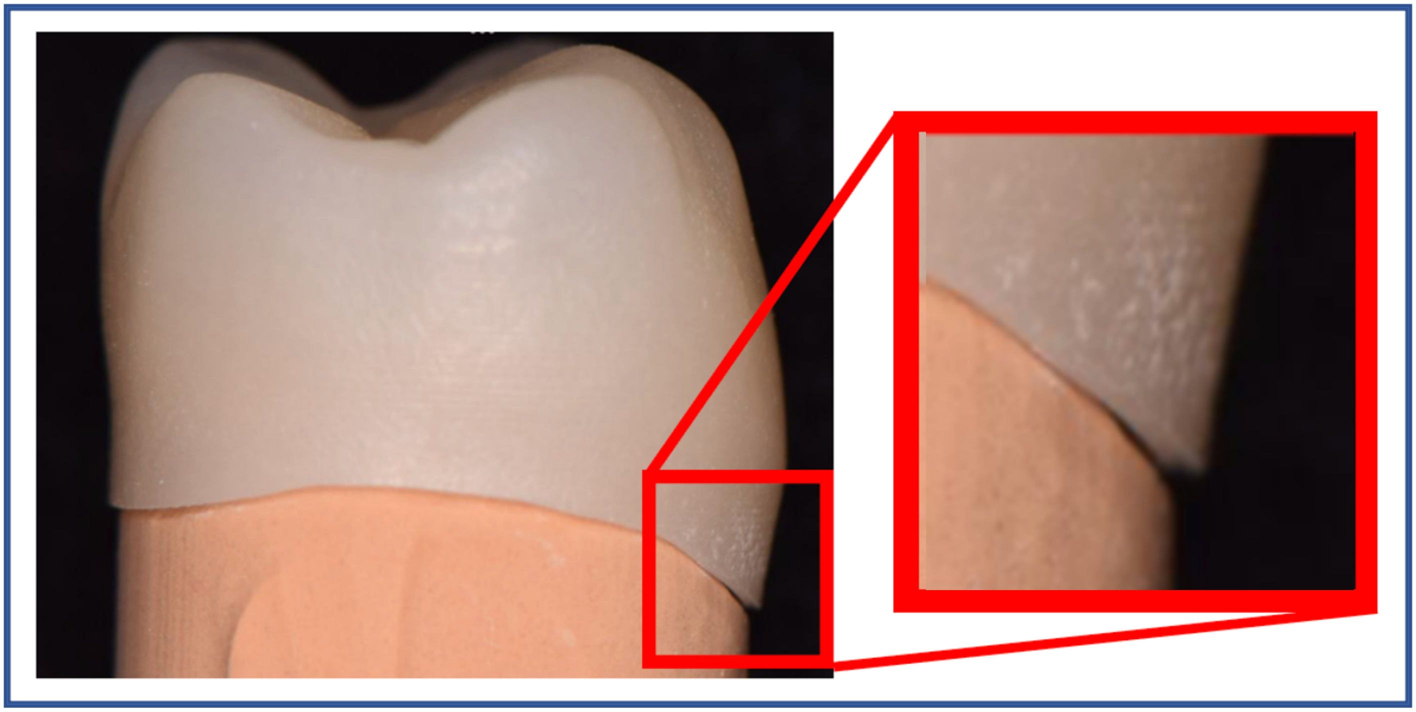

Figure 5: Open Margin on a Tight Crown

Figure 6: Loose Crown Rotated and Seated Incorrectly

Surprisingly, pressed lithium disilicate crowns, which were treated as the control group, had poorer rotational stability and were perceived as having greater open margins than the other groups. For reasons that time does not allow us to discuss here, we believe that there may be one or more confounding variables in the experiment methodology that we intend to pursue further. Overall, when asked whether they would deliver the crown in their private practice (Fig 7), reviewers most preferred the zirconia crowns with a larger cement gap space. However, no more than 70% of the crowns were deemed clinically acceptable for delivery in any of the groups.

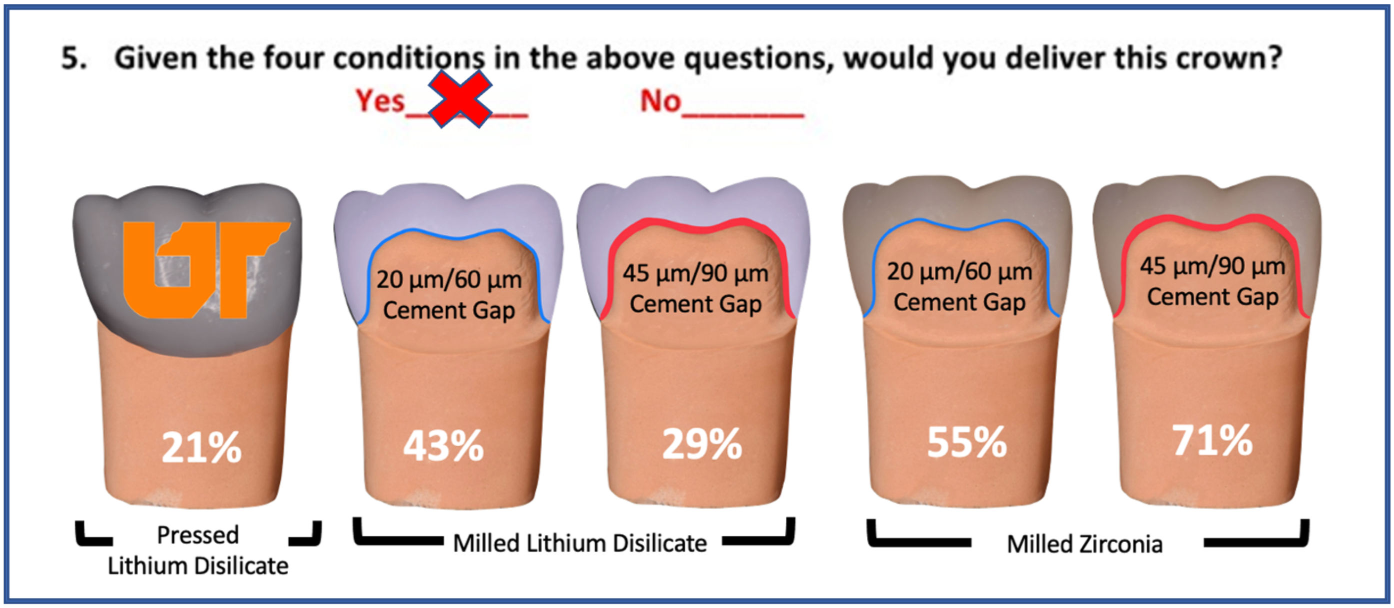

Figure 7: Clinician Opinion on Whether Crowns Should Be Delivered

Conclusions:

Within the limitations of this pilot study, and in the absence of statistical analysis, it was identified that controlled changes to cement gap space milling parameters in the design and fabrication of CAD/CAM crowns are clinically noticeable in terms of marginal gap and fit/rotational stability. While universal guidelines for the computer settings that designate these milling parameters are elusive, clinical providers are obligated to familiarize themselves with new methodologies so that problems can be identified and addressed with their respective laboratories to provide quality outcomes. Future research will aim to evaluate the statistical significance of the data resulting from this study and to expand these findings to pair with quantitative methods of analysis. It is our hope that this work can contribute to the body of knowledge seeking to pair appropriate clinical standards with advancing production technology.

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Acknowledgments:

Paul J Cascone BE MetE, MS (Senior Vice-President of Research and Development, Argen)
Donnie Bridges, CDT (Eastern Regional Sales Manager, Argen)
Cindy Deaton, CDT, UTHSC Advanced Prosthodontics
Dr. Scott Hollis, Assistant Program Director, UTHSC Advanced Prosthodontics
Dr. Angi Gullard, UTHSC Advanced Prosthodontics
Survey Participants, UTHSC Faculty and Residents