Technical Introduction

Method of Objectively Evaluating Tooth Preparation during Clinical Training

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Clinical significance
In order to increase the efficacy of clinical prosthodontic training, such as for crown preparation, the objective evaluation method described would be beneficial for providing specific instructions to each trainer as well as to track the longitudinal changes in clinical performance by residents.

ABSTRACT

Purpose : Evaluation of tooth preparation during clinical training of students and residents is prone to subjective judgments by instructors. The purpose of this study was to develop an objective method of evaluation using numerical criteria.

Materials and Methods : As the first step, phantom epoxy resin teeth (PC–23, Nisshin Inc., Japan) from the same lot were subjected to three-dimensional morphometry using a high-speed laser scanner (Surfracer, Unisn, Osaka, Japan). A 3-D reconstruction was then made using the digitized data for each tooth. These data were superimposed with the reference axis at a right angle to the center of the base of the teeth. The taper angle of the preparation surface was evaluated every 45° around the axis, and the position of the margin was evaluated every 5° compared with data obtained from the instructor’s standard preparation. Evaluations were made using numerical parameters.

Discussion : One tooth was prepared by an instructor (IN) and one by a resident at the beginning of the training (R 0) and after three months of training (R 3). The mean difference in the taper of the preparation between IN and R 0 was +14.8°, while it was +2.7° between IN and R 3. The difference in the margin location between IN and R 0 at the 72 sites was 118.1 mm, while it was 78.8 mm between IN and R 3. The value of the margin was determined by the differences between IN and R (R 0, R 3) preparations.

Conclusion : Using the difference in the numerical values between the abutment teeth, an objective and longitudinal evaluation is possible for technical assessment of tooth preparation during clinical training.

Key words

Tooth preparation, objective evaluation, clinical training, three-dimensional morphometry

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INTRODUCTION

The amount of actual tooth preparation training under the direction of instructors has gradually decreased during undergraduate clinical training before the national qualifying exams in Japan\(^5\). This reduction in training may be explained by the fact that practical instruction, in which students undergo clinical training with patients, is gradually shifting from undergraduate programs to postgraduate programs. This shift occurred in response to the enactment of a law taking effect in 2006 that requires at least one year of postgraduate clinical training.

Although some attempts have been made to change the system\(^2-7\), crown preparations are still generally evaluated by instructors' subjective observation because some facts are difficult to express objectively. Since tooth preparation is not taught objectively, it is difficult to make an evaluation and compare the preparations among students and residents. It is also difficult to measure the progress of each resident over time or to instruct the students how they could improve. However, tooth preparation training in the clinical setting is more practical and desirable than conventional training using a simulator on the bench\(^8\).

The purpose of this study was to develop a method of quantitatively and objectively evaluating tooth preparation done by residents on simulators in the clinical setting using numerical parameters determined by three-dimensional (3-D) morphometry.

MATERIALS AND METHODS

1. 3-D morphometry

Phantom epoxy resin teeth (PC-23, Nisshin Inc., Japan) from the same lot were subjected to 3-D morphometry using a high-speed laser scanner (Surflaser VF-15, UNISN, Japan) (Fig. 1) with a sensitivity of up to 50 μm. The teeth were fixed using a specially fabricated jig to standardize the positioning. Then the 3-D reconstruction was performed for each tooth using the digitized data from a software program (SURFLACER, VMS-100 F, UNISN).

2. Superimposition of 3-D data

Since the same lots of epoxy teeth were used, the 3-D digitized data were superimposed with the reference axis at a right angle to the center of the base of the tooth. The reference was determined as the intersection of the lines indicating the maximum buccal-lingual and mesio-distal width of the cross section of the model tooth 2 mm below the cemento-enamel junction (Fig. 2).

3. Parameters for the evaluation of the tooth preparation

1) Taper of the preparation

The taper of the prepared teeth was measured at eight points on the four cross sections produced by successively rotating the plane around the reference axis of the teeth by 45° from the mesial side (Fig. 3). The taper of the prepared teeth was regarded as the angle between the reference axis and the line connecting the
points on the top and bottom parts of the prepared surface. Cross sections with undercuts were excluded from the measurements.

Evaluation of the taper data was accomplished by comparing it with the instructor's standard data. The results were demonstrated on an octagonal radar chart.

2) Determination and evaluation of the margin location

The margin was determined at the inflection point on the image from 72 sites on 36 cross sections, which was produced by rotating the plane around the reference axis of the prepared tooth every 5° from the mesio-buccal corner (Fig. 4). Since each tooth was fixed at the standardized position, comparison of the vertical position for each marginal point was possible by the distance from an arbitrary horizontal plane on

the jig. The distance between the prepared tooth and the instructor's standard was calculated and expressed on a line graph. By adding the distances at the 72 sites between the two preparations, the representative value of the margin location for the preparation was determined.

3) Difference from the conventional method

Since tooth preparation is an irreversible procedure, sufficient training time is necessary for students and residents. Conventional tooth preparation training using a simulator is helpful but it differs from training in the clinical setting. Practical training in tooth preparation that is similar to clinical treatment, as found in our method, is necessary.

Evaluation of tooth preparation, which is usually done subjectively, should be performed more objectively so that students and residents can understand their deficiencies and thus make progress and achievements in their clinical training. Using the numerical evaluation of tooth preparation as proposed in this report, specific instructions, comparisons among students’ performance, and objective progress reports are easily provided by the instructors.

There are many other parameters for tooth preparation than those selected in this study; however, the taper and margin locations are
considered to be the most important in clinical practice to ensure a better fit of restorations as well as better retention\textsuperscript{15–17}. Differences in taper and margin positions can be numerically and visually evaluated in our method. Areas such as mesial and distal proximal margins, where the biological width concept\textsuperscript{18,19} should strictly be followed, can be visually monitored or displayed. Also the longitudinal objective evaluation for a specific group or individual is possible using these numerical values.

**Performance**

To confirm the effectiveness of this method, the following preliminary experiment was conducted.

1. Preparation

Three epoxy resin teeth from the same lot were used. One tooth was prepared by an instructor with 15 years of clinical experience (IN) and was designated as the standard model with a conventional chamfer margin, reduction of the occlusal surface according to anatomical morphology and an 8-degree axial taper. One tooth was prepared by a first-year resident at the beginning of the training (R 0) and another was done after 3 months of training (R 3). The preparations were done on the simulator with a phantom dental arch model (Simple Manikins, Nissim, Kameoka, Japan) set on a dental chair simulating the clinical environment (Fig. 5).

2. Data evaluation

1) Taper preparation

Figure 6 shows the radar chart of the taper angle of R 0 and R 3 at every 45° point using the IN data (the mean taper was 9.2°) as the reference. Each R 0 and R 3 value was normalized by the IN data at the same point with a 10-point scale. The mean difference between IN and R 0 was +14.8°, while it was +2.7° between IN and R 3.

2) Margin location

Figure 7 is a line graph showing the position of the margin on the ordinate and the distance from the reference plane. The margin location of R 0 was always shallower than IN. The representative value of the margin determined by the differences between the IN and R 0 preparation at the 72 sites added up to 118.06 mm. The R 3 margin location became deeper and closer to IN with the difference between the values of 78.81 mm. By using these numerical data, longi-

![Fig. 5](Image)

**Fig. 5** Simulator with phantom dental arch model set on a dental chair simulating the clinical environment

![Fig. 6](Image)

**Fig. 6** Radar charts of axis angle of prepared teeth at 8 locations for R 0 and R 3 with the instructor’s data as a reference
tudinal differences reflecting the clinical training could be presented visually and statistically.

CONCLUSION

It was possible to visually compare the degree of taper and the position of the margin of the teeth prepared by residents with the model produced by the instructor. Using the differences in the numerical values employed in this study, we were able to develop an objective evaluation system that can be used for technical and general assessments of tooth preparation during clinical training.

REFERENCES