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# EVALUATING THE ACCURACY OF MASTER CASTS OF COMPLETE DENTURES PREPARED USING A NEW SIMPLIFIED BEADING AND BOXING PROCEDURE FOR ELASTOMERIC IMPRESSIONS

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## ABSTRACT

**Background:** The accuracy of a master cast depends not only on the impression material and tray, but also on how the impression is supported and poured. Conventional wax boxing is difficult with elastomeric impressions because wax does not reliably adhere to their surfaces. A simplified plaster–pumice approach may provide a practical alternative while preserving the peripheral anatomy recorded in the impression.

**Objective:** To evaluate the accuracy of master casts produced from elastomeric complete-denture impressions using a new simplified beading and boxing procedure and an inexpensive, clinically applicable grading system.

**Methods:** This descriptive cross-sectional study was conducted in the Department of Prosthodontics, Liaquat University of Medical and Health Sciences, from 4 October 2022 to 4 April 2023. Ninety-six patients aged 45–75 years requiring a maxillary or mandibular complete denture were selected through consecutive sampling. Secondary elastomeric impressions were supported with a 1:1 plaster–pumice mixture, trimmed to establish the desired land area, boxed with wax, and poured with Type III dental stone. Casts were assessed using a predefined four-grade system based on cast thickness, land dimensions, vestibular depth, border extension, repositioning indices, surface finish, and dimensional deviation. Grades A and B were considered acceptable; grades C and D were considered compromised.

**Results:** The mean age of participants was 54.28 ± 6.26 years; 43 (44.8%) were male and 53 (55.2%) were female. Grade A, B, C, and D casts accounted for 44 (45.8%), 23 (24.0%), 20 (20.8%), and 9 (9.4%) cases, respectively. Overall, 67 of 96 casts (69.8%; 95% CI: 60.0–78.1%) were classified as acceptable, whereas 29 (30.2%) were classified as compromised. Acceptable accuracy did not differ significantly according to age group ($p = 0.275$) or sex ($p = 0.652$).

**Conclusion:** The new simplified plaster–pumice beading and boxing procedure produced acceptable master casts in approximately seven out of ten cases. It uses readily available laboratory materials, does not require a separating medium, and offers a practical method for preserving impression borders during cast fabrication. Prospective comparative studies with objective dimensional measurements and operator calibration are needed before the technique can be recommended as a standard protocol.

**KEYWORDS:** complete denture; elastomeric impression; master cast; beading; boxing; plaster–pumice; prosthodontics

## INTRODUCTION

The master cast is the positive cast that is used to design and make the complete denture. Its quality impacts beyond the convenience of the lab; loss of vestibular depth, distortion of the peripheral roll, insufficient land area, and the cast base being uneven can negatively affect the accuracy of the denture base and place a greater adjustment burden on the clinician. The master cast must reflect the supporting anatomy as well as the functional limits of the denture-bearing tissues during the border molding process, and complete-denture treatment relies on an accurate record of the denture-bearing tissues (1, 2).

The purpose of beading and boxing the borders of an impression is to maintain the extension and thickness of the borders, and to create a controlled base impression form. Boxing also provides a uniform cast thickness, minimizes the need for unnecessary trimming, aids in remounting and can minimize stone wastage. Wax boxing will work well with certain rigid impression materials, especially zinc-oxide impression paste, but is technically challenging with elastomeric impression materials as wax does not adhere in a predictable way to the surface of these materials. There has been some description of adhesive-assisted techniques, which add to the handling procedures and may lead to skin irritation, wax distortion or an uneven cast base (3, 4).

There are a number of alternatives such as plaster–pumice support, caulking compounds, modeling materials, preformed boxes, thermoplastic rings, irreversible hydrocolloid and adhesive-based procedures. They all serve the same general function of stabilizing the impression and ensuring the peripheral anatomy during pouring. There are, however, many techniques which involve the use of extra materials, special components or the experience of the operator. A simple method that can be easily carried out with the available materials in dental labs and can be assessed by a reproducible clinical grading system is still needed (5-7).

A new simplified beading–boxing method was tested in the present study in which initial support around the impression is given by a plaster–pumice mixture and then the wall is shaped with wax. A four-grade clinical assessment system, which incorporates clinically relevant dimensions and surface characteristics, was also used in the study. The major outcome was the percentage of master casts that were determined to be acceptable (grades A or B).

## MATERIALS AND METHODS

### Study design and setting

A descriptive cross-sectional study was conducted in the Outpatient Department of Prosthodontics, Institute of Dentistry, Liaquat University of Medical and Health Sciences, Jamshoro/Hyderabad, Pakistan. The study was carried out over a six-month period, from 4 October 2022 to 4 April 2023. The study evaluated the quality of master casts prepared from elastomeric complete-denture impressions using a new simplified beading and boxing technique.

### Participants and sampling

Participants were selected through non-probability consecutive sampling. Patients aged 45–75 years, irrespective of sex, who required a complete denture for either the maxillary or mandibular arch were considered eligible. A satisfactory secondary impression of either arch was required for inclusion.

Patients were excluded if the impression showed inadequate border molding, visible voids, bubbles, or other defects that could influence the assessment of the resulting cast. Master casts that were broken, damaged, or contained voids, bubbles, or other major defects were excluded from the final evaluation. Each participant contributed one master cast, which served as the unit of analysis.

### Sample size estimation

The sample size was calculated using a 95% confidence level, an anticipated Grade A proportion of 46.66% obtained from a preliminary pilot assessment (3), and a 10% margin of error. The resulting minimum sample size was 96 participants. This number was subsequently used for the evaluation of 96 master casts.

### New Simplified beading and boxing procedure

After the border molding, a second impression was taken with an elastomeric impression material. Excess water was removed from the impression and the impression itself was disinfected prior to the beading and boxing process. Using a permanent marker, a line was drawn around the perimeter of the roll about 3 mm away to denote the intended length of the master cast.

A glass slab was used to make a plaster mixture of plaster of Paris and pumice 1:1. The impression was set at an angle, so that the ridge area was mostly parallel to the bench surface. The marked outer areas were kept about 3-4mm above the plaster/pumice mixture. This mixture was then shaped around the impression to create a beading area of about 3-4 mm width. The interlingual or tongue space area was also reinforced with plaster–pumice mixture for mandibular impressions. Once it had set it was cut to the thickness of the beads. To split the plaster–pumice support, an undercut was made to allow the removal of the master cast after setting. The plaster–pumice beading was adapted to modeling wax, with the lingual region if applicable. Boxing wax was then moulded around the impression, at least 13 mm above the beading.

No medium used for separation. The boxed impression was then filled with type III dental stone. Once the stone had set, the boxing wax was melted off and the master cast was slowly recovered and inspected.

### Assessment of master-cast accuracy

| Grade | Operational criteria |
|---|---|
| A | Base parallel to the residual ridges; thinnest cast areas 11–13 mm; land areas clearly defined, 3–4 mm wide (4–6 mm at the posterior mandibular border), beveled approximately 30–45°, and no more than 2 mm above the vestibular depth; vestibules 1–3 mm deep; all denture-supporting areas preserved; repositioning indices approximately 10 mm wide and 3–5 mm deep; tongue space flat and smooth; dimensional deviation within ±0.5%; clean, smooth cast without voids or blebs. |
| B | Minor deviations from Grade A that were not expected to compromise denture fabrication; dimensional deviation within ±1.5%. |
| C | Clinically usable but marginal cast, with inadequate thickness, land contour or width, insufficient vestibular depth, incorrectly proportioned repositioning indices, residual wax, or an unclean surface; dimensional deviation within ±3%. |
| D | Cast unsuitable for clinically acceptable complete-denture fabrication, including a broken cast or a cast that required gluing for recovery. |

Each master cast was evaluated using a predefined four-grade assessment system. Measurements were obtained using a simple ruler or digital vernier caliper. The assessment included cast thickness, land-area width and contour, vestibular depth, border extension, repositioning indices, tongue-space form, surface finish, and the presence of voids, blebs, residual wax, or other visible defects. Dimensional deviation was assessed according to the predefined grading criteria.

For statistical analysis, Grades A and B were combined and classified as acceptable accuracy, whereas Grades C and D were combined and classified as compromised accuracy.

**Data collection**

A proforma was used to record the data. Information gathered comprised the age, sex, jaw involved, BMI category, impression material, operator experience, time of procedure, cast grade, land area characteristics, surface finish, border sharpness, cast thickness, vestibular depth, repositioning indices, and other dimensional features of the cast. Ages were recorded in completed years and grouped into three categories: ≤50 years, 51-60 years and >60 years. Male and female were recorded. BMI was classified as normal, overweight or obese based on the predetermined criteria of the study. The impression materials were categorized as either addition silicone or condensation silicone. Operator experience was divided into ≤5 years, and >5 years, and procedure duration into ≤12 minutes, and >12 minutes. The main results were the percentage of master casts that were considered acceptable with regards to accuracy as per Grade A and B. The secondary outcome was the distribution of casts on Grades A, B, C and D.

**Statistical analysis**

Data were entered and analyzed using IBM SPSS Statistics version 21.0. Continuous variables were summarized using the mean and standard deviation, while categorical variables were presented as frequencies and percentages. The proportion of acceptable and compromised casts was calculated with corresponding 95% confidence intervals.

Associations between acceptable master-cast accuracy and categorical variables were assessed using the chi-square test or Fisher's exact test, as appropriate. For the multivariable analysis, acceptable accuracy was entered as a binary dependent variable, with Grades A and B coded as acceptable and Grades C and D coded as compromised. Binary logistic regression was used to estimate crude and adjusted odds ratios with 95% confidence intervals. The reference categories were age group 51–60 years, female sex, normal BMI, addition silicone, operator experience >5 years, and procedure duration ≤12 minutes. The adjusted model included the participant and procedural characteristics presented in Table 2. Adjusted odds ratios below 1.0 indicated lower observed odds of acceptable master-cast accuracy compared with the relevant reference category. Statistical significance was assessed using a two-sided p value of $<0.05$.

## RESULTS

Among the 96 evaluated master casts, Grade A was the most frequently observed category, accounting for 44 (45.8%) casts, followed by Grade B with 23 (24.0%), Grade C with 20 (20.8%), and Grade D with 9 (9.4%). When Grades A and B were combined, 67 (69.8%) casts were classified as acceptable, whereas 29 (30.2%) were classified as compromised based on Grades C and D. The 95% confidence interval for acceptable casts was 60.0%–78.1%, while that for compromised casts was 21.9%–40.0%. Overall, the acceptable-to-compromised cast ratio was approximately 2.3:1, indicating that acceptable master casts constituted the majority of the evaluated specimens. **Table 1.**

**Table 1. Overall distribution and comparative classification of master-cast accuracy**

| Accuracy grade/category | Interpretation | Frequency, n | Percentage, % | 95% CI |
|---|---|---|---|---|
| Grade A | Excellent accuracy | 44 | 45.8 | 35.9–56.0 |
| Grade B | Acceptable accuracy | 23 | 24.0 | 16.3–33.6 |
| Grade C | Compromised accuracy | 20 | 20.8 | 13.9–30.1 |
| Grade D | Severely compromised accuracy | 9 | 9.4 | 4.9–17.1 |
| Acceptable casts (A+B) | Acceptable accuracy | 67 | 69.8 | 60.0–78.1 |
| Compromised casts (C+D) | Compromised accuracy | 29 | 30.2 | 21.9–40.0 |
| Total | — | 96 | 100.0 | — |

Acceptable accuracy was observed in 25/38 participants aged ≤50 years (65.8%), 32/41 aged 51–60 years (78.0%), and 10/17 aged >60 years (58.8%; p=0.275). The corresponding proportions were 67.4% in males and 71.7% in females (p=0.652). Acceptable accuracy was 75.0% among participants with normal BMI, 74.4% among those who were overweight, and 58.6% among those with obesity. Higher proportions were also observed with addition silicone compared with condensation silicone (75.0% vs. 63.6%), among operators with >5 years of experience compared with ≤5 years (75.9% vs. 60.5%), and when procedures were completed within 12 minutes compared with >12 minutes (77.8% vs. 54.5%). In the multivariable logistic regression analysis, obesity, condensation silicone, ≤5 years of operator experience, and procedure duration >12 minutes demonstrated lower adjusted odds of acceptable accuracy; however, none of the associations was statistically significant, with all 95% confidence intervals including 1.0. **Table 2.**

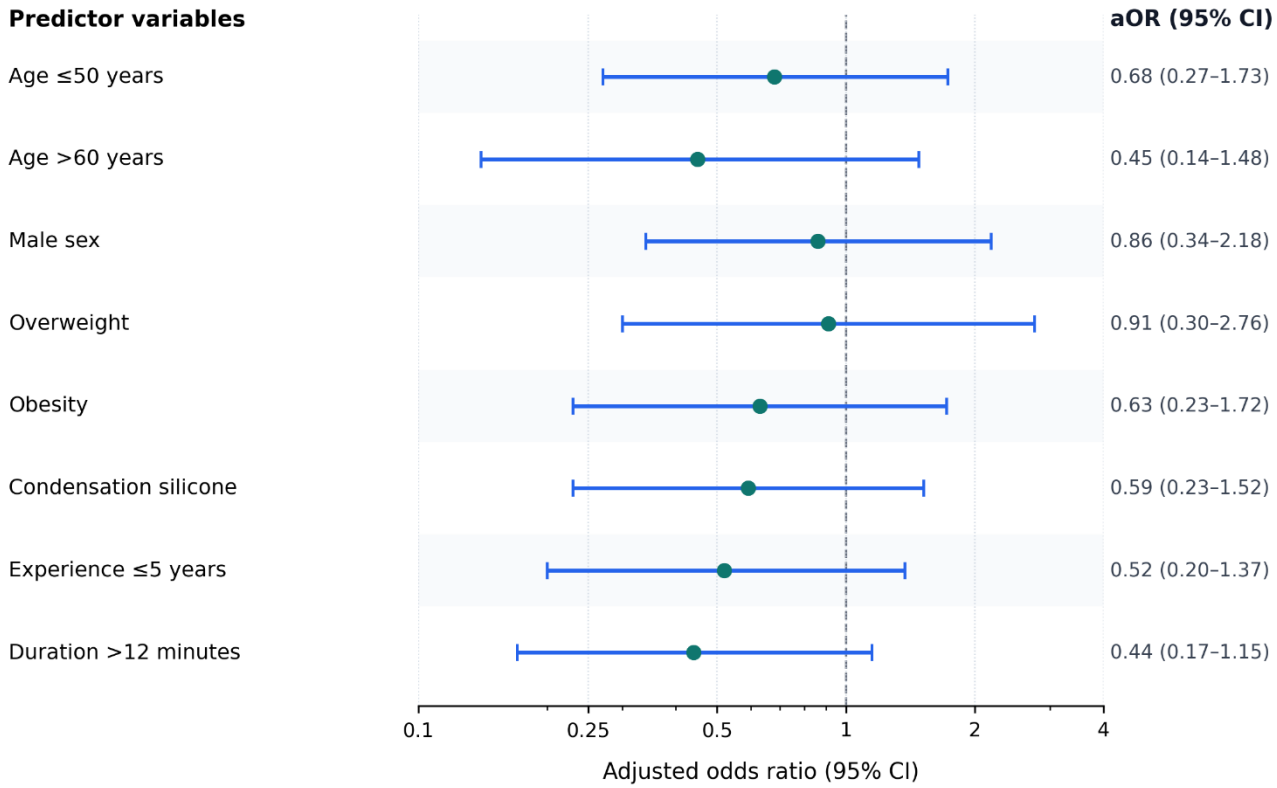
**Table 2. Comparative distribution and regression analysis of acceptable master-cast accuracy**

| Variable | Category/reference comparison | Acceptable casts, n (%) | Compromised casts, n (%) | OR | Adjusted OR | 95% CI for adjusted OR; p value |
|---|---|---|---|---|---|---|
| Age group | ≤50 years | 25 (65.8) | 13 (34.2) | 0.54 | 0.68 | 0.27–1.73; 0.421 |
| | 51–60 years (reference) | 32 (78.0) | 9 (22.0) | 1.00 | 1.00 | Reference |
| | >60 years | 10 (58.8) | 7 (41.2) | 0.40 | 0.45 | 0.14–1.48; 0.188 |
| Sex | Male | 29 (67.4) | 14 (32.6) | 0.82 | 0.86 | 0.34–2.18; 0.748 |
| | Female (reference) | 38 (71.7) | 15 (28.3) | 1.00 | 1.00 | Reference |
| BMI category* | Normal BMI (reference) | 21 (75.0) | 7 (25.0) | 1.00 | 1.00 | Reference |
| | Overweight | 29 (74.4) | 10 (25.6) | 0.97 | 0.91 | 0.30–2.76; 0.868 |
| | Obese | 17 (58.6) | 12 (41.4) | 0.47 | 0.63 | 0.23–1.72; 0.366 |
| Impression material* | Addition silicone (reference) | 39 (75.0) | 13 (25.0) | 1.00 | 1.00 | Reference |
| | Condensation silicone | 28 (63.6) | 16 (36.4) | 0.58 | 0.59 | 0.23–1.52; 0.273 |
| Operator experience* | >5 years (reference) | 44 (75.9) | 14 (24.1) | 1.00 | 1.00 | Reference |
| | ≤5 years | 23 (60.5) | 15 (39.5) | 0.49 | 0.52 | 0.20–1.37; 0.190 |
| Procedure duration* | ≤12 minutes (reference) | 49 (77.8) | 14 (22.2) | 1.00 | 1.00 | Reference |
| | >12 minutes | 18 (54.5) | 15 (45.5) | 0.34 | 0.44 | 0.17–1.15; 0.092 |

*OR, odds ratio; CI, confidence interval.*

Figure 1 demonstrates the adjusted odds ratios for acceptable master-cast accuracy across the evaluated participant and procedural characteristics. The adjusted odds of acceptable accuracy were lower among participants aged >60 years (aOR 0.45, 95% CI 0.14–1.48), those with obesity (aOR 0.63, 95% CI 0.23–1.72), casts prepared using condensation silicone (aOR 0.59, 95% CI 0.23–1.52), operators with ≤5 years of experience (aOR 0.52, 95% CI 0.20–1.37), and procedures exceeding 12 minutes (aOR 0.44, 95% CI 0.17–1.15). However, all confidence intervals crossed the null value, indicating that none of the evaluated factors demonstrated a statistically significant independent association with acceptable master-cast accuracy.

**Figure 1. Forest plot of adjusted factors associated with acceptable master-cast accuracy**




***The reference value is OR=1.0; values below 1.0 indicate lower observed odds of acceptable cast accuracy.***

## DISCUSSION

The purpose of this study was to evaluate a modified plaster–pumice beading and boxing technique for elastomeric complete-denture impressions. Acceptable master casts were produced in 69.8% of cases with a grading system related to clinically meaningful cast dimensions and surface characteristics. The findings indicate that the procedure can yield a usable cast in a significant percentage of routine clinical cases, while 30.2% of casts were deemed as compromised and would need further review and/or intervention. The major application of the method is the ability to separate the role of support and boxing. The poor adhesion of wax to elastomeric materials is overcome by the use of a plaster–pumice mixture to stabilize the impression. Pumice also reduces the strength of the set plaster matrix and can lead to easier recovery of the cast without too much force. No separating medium is required and materials found in dental laboratories are used (8-10).

The results are in line with the overall concept of beading and boxing as stated in prosthodontic literature, namely, to maintain peripheral roll, control the thickness and shape of the cast base, maintain the vestibular anatomy, minimize trimming, and ease subsequent laboratory work (11, 12). Previous methods have included the use of wax, caulking materials, modeling clay, preformed boxes, irreversible hydrocolloid, adhesive systems and reusable rings (13). These techniques vary in terms of cost, availability, handling requirements and potential distortion. The present method is designed to take advantage of the simplicity of wax boxing while avoiding the adhesion issue found with elastomeric impressions.

Another pertinent aspect of the study is the four-grade system. There are methods using high resolution microscopy, digital scanning and simulation techniques that can give detailed dimensional information, but in many teaching or clinical laboratories these may not be available. Ruler or digital vernier caliper is relatively inexpensive and readily available. However, there is some operator dependency, especially in the judgment of smoothness, border contour and if a deviation is considered clinically acceptable or not. No information on calibration between assessors was reported and should be added to future work, nor were data on the intra- and interobserver reliability reported.

There was no significant difference in the degree of cast accuracy between age groups or sex. These variables are not likely to directly influence the dimensional accuracy of a cast but may serve as surrogate variables for anatomic variations of the impressions or tissue form or clinical situations. Furthermore, there is no statistical relationship, so the lack of association should not be taken as an indication of the ease in which all impressions can be boxed or poured. The influence of operator experience, use of a specific impression material, setting time, pouring time, tray design, and jaw specific differences were not investigated sufficiently in the study to determine if they have independent effects (14, 15).

There are some limitations of the study. It was performed in one institution, by consecutive non-probability sampling and without a control group with a conventional boxing method. No direct comparison of the accuracy, cost, time or cast strength can be made between the different methods as there is no design control for this. The primary outcome was not a validated

reference-standard measure. Moreover, the distribution of impressions of maxillary and mandibular teeth, the number of operators, examiner calibration, exact impression materials, stone-water ratios, setting times, and the number of individual dimensional defects was not reported in the dissertation. The lack of these omissions makes it difficult to reproduce the results and would need to be resolved in a confirmatory study.

**CONCLUSION**

Within the limitations of this single-center cross-sectional evaluation, the new simplified plaster–pumice beading and boxing procedure produced acceptable master casts in 67 of 96 cases (69.8%). The method is inexpensive, uses readily available materials, does not require a separating medium, and is designed to preserve the peripheral anatomy of elastomeric impressions. It should be regarded as a promising practical technique rather than a definitive replacement for established procedures. Future comparative studies should include a conventional control method, standardized operator training, objective three-dimensional measurements, procedure time, material consumption, and examiner reliability.

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