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Factors that influence the quality of final impressions for fixed dental prostheses in Nairobi, Kenya

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Abstract

Background: Good quality dental impressions free of air bubbles, voids, steps, drags, streaks and tears are a pre-requisite for the fabrication of well-fitting fixed dental prostheses (FDP). The quality of impressions is dependent on clinician and material factors.
Aim: To evaluate factors that influence the quality of final impressions for FDP in Nairobi, Kenya.
Methods: In this cross-sectional study, 234 impressions received by five dental laboratories were analyzed. The study collected information on the type of tray, impression material, technique, type of prostheses, and clinically detectable errors, including voids, inadequate material at margins, tears, steps, drags, and streaks. Impression quality was the outcome assessed as good, fair, or poor by two investigators. The independent variables influencing impression quality included clinician specialty, experience, impression material, technique, and tray type.
Results: Inter-rater agreement was 96.8% ($p<0.001$). Clinician experience ranged between 1-45yrs, median 13.5yrs and mean 8.39±11.96yrs. The majority were GPs, 80.8% while restorative dentists were 11.5% and other specialists, 7.7%. Most impressions were non-aqueous elastomers, 97.9% employing dual-viscosity technique, 75.6%. Impression trays included stock metal, 60.3%, stock plastic, 34.2%, and custom, 5.5%. Impression quality was good, 24.8%, fair, 37.2% or poor, 38.0%. Cumulatively, 74.5% impressions had bubbles/voids, 53.0% tears and 43.2% poor margins. Clarity of margins was associated with clinician specialty, (Fisher's exact=9.372, p=0.047), and impression technique with impression quality, (Pearson's $\chi2$ = 6.385, p=0.041). Compared to restorative specialists, estimated odds of other specialists producing poor margins was 5.71, 95%CI 1.55,21.06, Wald $\chi2$=5.24, p=0.009 while for GPs, the estimated odds was 2.19, 95%CI 0.88, 5.43, Wald $\chi2$ = 2.86, p=0.09. Compared to dual viscosity, estimated odds of monophase giving a poor-quality impression was 1.52, 95%CI 0.83,2.78, Wald $\chi2$ = 1.52, p=0.18.
Conclusion: Most impressions were good or fair hence acceptable. Quality of impressions was influenced by clinician specialty and impression technique.

Keywords: Partial edentulism, fixed dental prostheses, dental impressions, impression quality, dental impression errors.

1. Introduction

Partial edentulism is the loss of one or more but not all teeth due to caries, periodontal disease, traumatic injuries, cultural and neoplastic and cystic lesions among other factors [1]. Tooth loss is associated with aesthetic, psychological, social and functional implications on individuals, thus affecting quality of life. Globally, 60% of adults aged above 65 years are partially edentulous; the annual cost of managing edentulism runs to hundreds of billions of dollars [2]. Treatment options for partially edentulous patients missing single or multiple teeth, having severely damaged root-treated teeth and moderate to severe fluorosis range from a provisional removable acrylic partial denture, a definitive cast metal partial denture, indirect veneers, a post-retained core followed by an extra-coronal restoration, a resin-bonded prosthesis, to a fixed partial denture or an implant-supported/retained prosthesis [3].

An accurate final conventional or digital impression is a prerequisite to the fabrication of well-fitting fixed dental prostheses (FDP) hence a crucial determinant of successful treatment. A conventional impression should be made from homogenously mixed impression material that is free of air bubbles, voids, steps and drags [4], and should capture the preparation margins and finish lines, clearly demarcating their relationship with the gingivae [5]. The fundamental requirements of retention, stability and support of the FDP are dependent on an impression that appropriately replicates the teeth and adjacent soft tissues. Errors and deficiencies on the cervical margin can be caused by bleeding, moisture contamination or inadequate retraction of the gingival tissue, resulting in poor fit, open margins, plaque retention, cervical caries and consequently poor prognosis of the restoration. Further, the use of a non-rigid plastic stock tray may cause impression errors due to deformation from pressure changes during and after withdrawal of the impression, resulting in a restoration with open margins [6].

Thus, the quality of an impression is dependent on factors relating to the patient, material, clinician or laboratory technologist [7]. Patient tissue factors that may contribute to errors in final impressions include subgingival finish lines due to aesthetic concerns and short clinical crowns, moisture in the oral cavity due to sialorrhea, gingival inflammation and bleeding [5, 8]. Material factors that affect the dimensional accuracy of elastomeric final impression include the type of impression material, adhesion to the tray, viscosity, hydrophilicity, uniform thickness, by-product formation, elastic recovery, and polymerization/thermal shrinkage [9-11]. Incorrect manipulation of an ideal impression material such as inefficiencies in mixing, tray loading, syringing or tray seating may cause air bubbles in critical places while voids at the margins arise from either insufficient retraction or fluid accumulation preventing the impression material from flowing around the margins [6]. Clinician socio-demographic factors including age, experience and specialization are thought to influence the quality of final impressions for FDP with effects on long-term treatment outcomes [12]. Moreover, the quality of impressions and accuracy of margins were reported to be significantly better in work among dental students supervised by prosthodontists as compared to general practitioners (GPs) [13]. The impression tray must effectively constrain the material to prevent it from flowing away from critical areas thus inducing impression drags that are commonly seen on the distal aspects of teeth adjacent to edentulous spaces and in undercut regions [14]. Custom trays are preferred for FDP because they maintain a 2-4mm cross-section of the impression material to ensure uniform polymerization shrinkage and optimal accuracy [15]. Laboratory factors that may cause errors in impressions include delayed pouring or incorrect disinfection procedures [16].

Three impression techniques are commonly used to record conventional impressions: putty wash, dual viscosity and single viscosity [11,17]. The putty-wash impression technique pairs putty and light body impression materials to record in three ways: one-stage impression, where the putty and wash are recorded simultaneously (also called twin mix or laminate technique); two-stage unspaced, where the putty is recorded first and after setting relined with a thin layer of wash; and, two-stage spaced, where a polythene spacer sheet over the putty creates space for the wash. The two-stage putty wash technique is preferred due to accuracy [9,11]. In the single-step dual viscosity technique, a low-consistency material is injected directly into critical areas while a high-consistency material is placed in an impression tray, where it forces the lower-viscosity material to flow into fine aspects of the areas of interest. The materials adhere and polymerize simultaneously, reducing chairside time, preventing wastage and yielding accurate impressions free of the drawbacks of low viscosity and high shrinkage of the syringed material [18]. However, unexpected early set of the light-body due to oral cavity temperature, insufficient loading of heavy-body into the tray and low insertion pressure are common causes of errors [19]. In a two-step version of the dual viscosity technique, a high-viscosity material is used for a preliminary impression, while the final impression is performed with a lower-viscosity material. Its disadvantages include dimensional alterations, extra chair time, and extra material required [20]. The monophase or single viscosity technique employs a medium viscosity impression material whereby the same material for the tray is syringed over the preparation by shear thinning [21]; however, there is a greater incidence of voids in monophasic impressions when compared with the dual viscosity technique [22].

Although digital impressions eliminate some errors that may arise from both the clinical as well as laboratory stages, they require substantial financial and skill investment that is eventually transferred to the patient; therefore, the majority of clinicians in low- and middle-income countries (LMIC) still rely on conventional dental impression materials and techniques [11]. Several studies on impression accuracy are available, the majority evaluating resultant dies rather than the actual impressions. Moreover, we did not come across any that concurrently sought to establish the factors affecting impression quality. Therefore, the aim of this study was to evaluate factors that influence the quality of final impressions for FDP in Nairobi, Kenya. The hypothesis under investigation was that there is no relationship between impression quality and clinician experience, specialty, impression material, impression technique and impression tray.

2. Materials and methods

2.1 Ethics approval and consent to participate

Ethical approval to conduct the study was obtained from Kenyatta National Hospital and University of Nairobi Ethics and Research Committee (KNH-ERC/A/403/2018). All participating laboratories provided written informed consent, and the study complied with all requirements of research involving human subjects.

2.2 Study population and sampling technique

In this analytical cross-sectional study, Fischer's formula was used to calculate a sample size of 248 final impressions for FDP recorded by dental practitioners and sent to five commercial dental laboratories in Nairobi, Kenya. A previous similar study indicated that 64.5% of impressions examined displayed at least one visible error [9]. The initial calculated sample size of 496 was reduced for a study population of <10,000 assuming an estimate of 500 impressions received during the study period based on records in the participating laboratories. All impressions for FDP received at the laboratories during the duration of the study (March to May 2019) were scrutinized and those deemed eligible were examined until the sample size was achieved.

Nairobi is the capital city of Kenya, an East African country. The urban location makes it popular for private dental practice due to the high population of more than five million people and a higher socioeconomic status than the rest of the country. Several private dental laboratories are located throughout the city and five well-known to have a high turnover of dental impressions were selected through snowballing sampling technique. Thereafter, all impressions for FDP that met the inclusion criteria were conveniently selected. The inclusion criteria were as follows: impressions at dental laboratories whose representatives consented to participate, all impressions for FDPs during the study period, impressions available prior to casting and after disinfection, such impressions made from elastic impression materials, by practitioners retained in the regulating council's register to practice in 2019. A flow chart detailing the selection criteria is shown in Figure 1. Impressions were evaluated after disinfection but before any other processing took place. In an impression spanning several abutments, a defect on one abutment was scored as a defect for the whole impression on the assumption that this could influence the treatment outcome for the complete prosthesis.

2.3 Data collection

Impressions were examined during the day under ambient room lighting. The principal investigator (MG) was trained and calibrated (by OO and KB) to collect information on the type of tray (stock or custom); type of impression material (hydrocolloid or non-aqueous elastomers); impression technique (monophase or dual phase, where impressions in one homogenous colour were assumed to be monophase while those bearing two colours were considered dual phase); type of prostheses (single crown, multiple unit FDP, implant); and, clinically detectable errors (voids or bubbles, inadequate impression material at the margins, tears, steps, drags or streaks).

A trained assistant used the laboratory prescription form accompanying the impressions to obtain data on specialty and duration of practice of the dentists who recorded the impressions, by cross-checking from the public online retention register of the regulator's website. To ensure the anonymity of the clinicians, this information was entered in coded serially numbered data collection sheets. Out of a sample size of 248, relevant details were available for only 234 clinicians hence these formed the final sample size for analysis.

A photograph of each impression was taken using a camera and macro lens (AF-S Micro Nikkor 105mm 1:2.8G ED, Sigma ring flash EM-140 DG, Nikon D3300, Tokyo, Japan) positioned on a stable platform 105mm from the impression, at 1:1 magnification and serialized corresponding to the data collection sheet. On Microsoft Paint (Windows 2013, Microsoft Inc, Washington, USA) at a magnification of 1.1, grid lines and an inbuilt ruler were used to determine the size of macroscopically visible errors on the photographs of the impressions. Samples of photographs of impressions are presented in Figures 2 and 3.

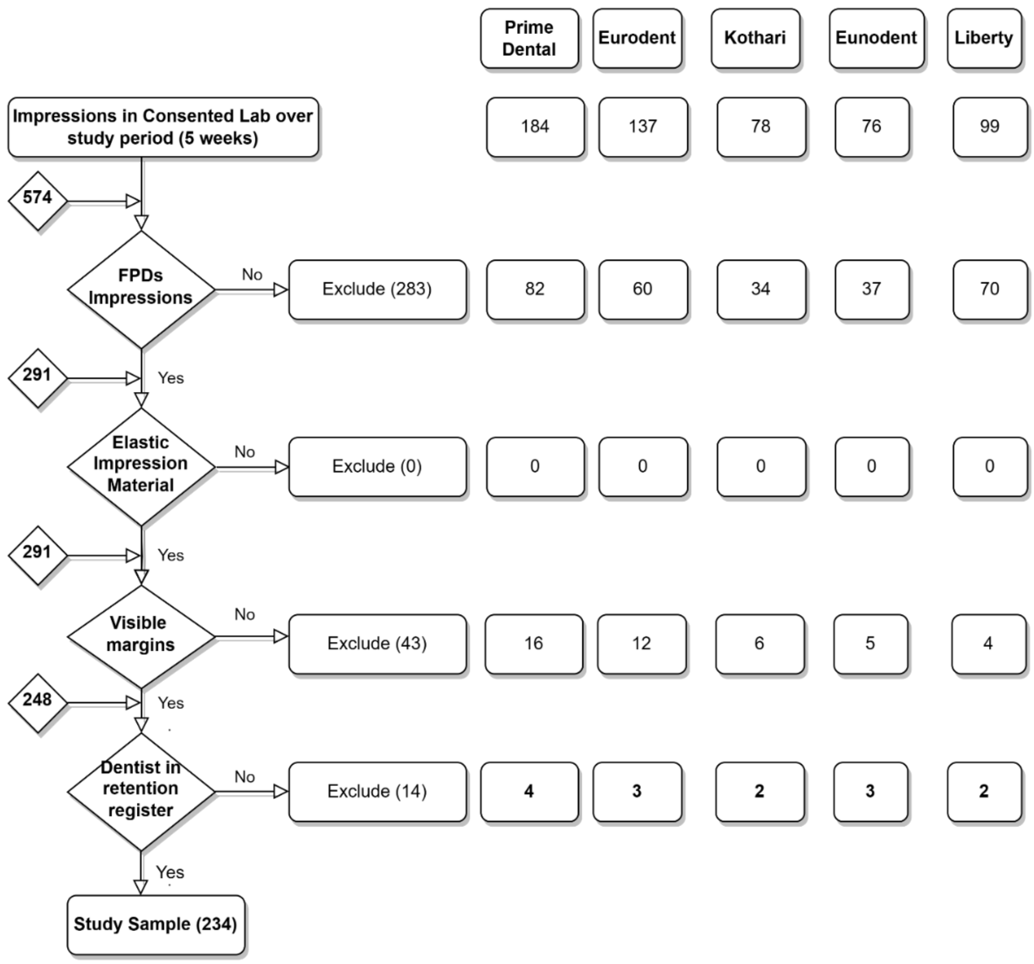

Figure 1. Flow chart of inclusion criteria of impressions evaluated in the study

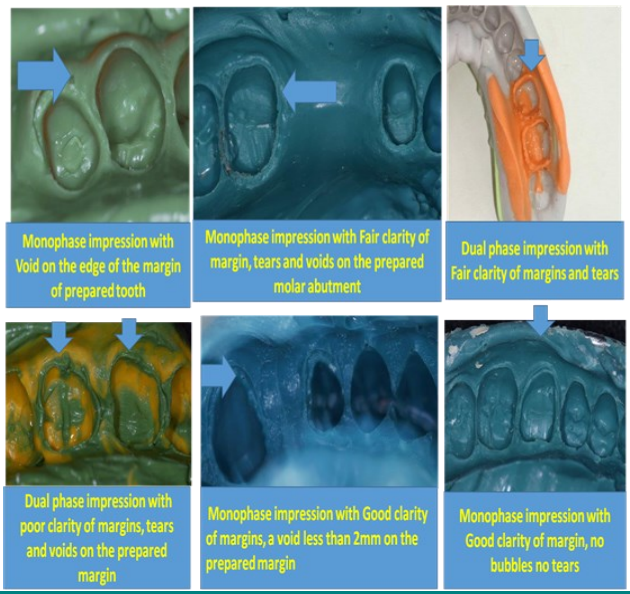

Figure 2. Sample of the impressions evaluated with description of the impression technique and errors.

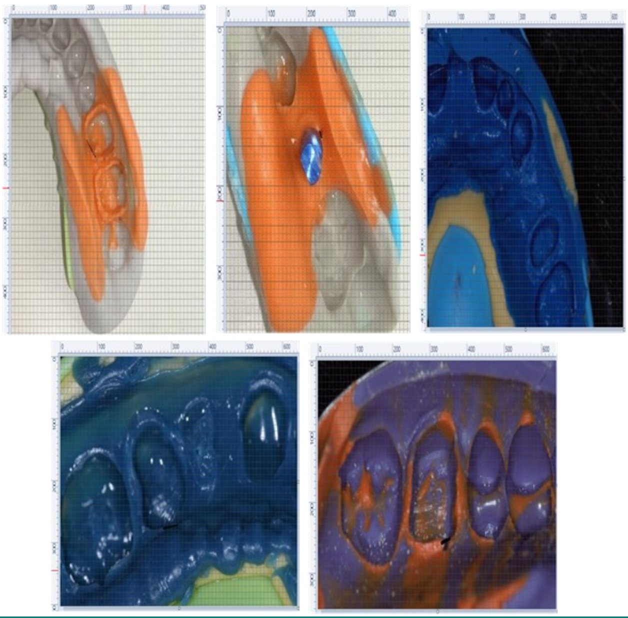

Figure 3. Sample of photographs of impressions showing gridlines and ruler used to measure visible errors

The presence and size of errors as well as the clarity of margin preparations were assessed independently by two investigators (MG and OO) to categorize the impression quality as good, fair or poor (κ = 0.968 (95% CI, 0.94, 1.0), p <0 .001 for inter-rater agreement). The mesial, distal, palatal, buccal and occlusal surfaces of the final impressions of prepared teeth and adjacent soft tissues were examined as adapted from Alhouri *et al.*[23] who considered a good quality impression as having teeth and soft tissues free of any distortions, homogeneous and margins with good clarity; a fair quality impression as having tears or bubbles <2mm, margins with fair clarity, a single streak of unmixed material; and, poor quality impression as displaying bubbles or tears >2mmm, margins with poor clarity and more than one streak of unmixed material.

2.4 Outcome and independent variables

The primary outcome variable was impression quality at the time of examination, expressed as good, fair or poor. This outcome was an ordinal variable of three categories based on the presence and extent of visible errors as well as clarity of margins: good quality, if prepared tooth/teeth had clear margins and surrounding soft tissues were free of any visible errors; fair quality if there were fairly clear margins and minimal distortions <2mm and not on the crucial areas; poor quality if there were poor margins and distortions anywhere on the impression >2mm. Clinician experience and specialty, impression material, impression technique and impression tray were independent variables. Clinician experience was a continuous variable expressed in number of years of practice. The rest were nominal variables described as follows: Clinician specialty, three categories – GP (1), restorative dental specialty (2), other dental specialty (3); impression material, two categories – irreversible hydrocolloid (1), non-aqueous elastomer (2), impression technique, two categories – monophase (1), dual-phase (2); impression tray, three categories – metal stock tray (1), plastic stock tray (2), custom made acrylic tray (3).

2.5 Statistical Analyses

Data were analyzed using SPSS 25 (IBM). Descriptive statistics were presented in the form of frequencies, proportions, means, standard deviations, medians, and ranges in tables. Chi-square and Fisher's exact test for categorical variables and, independent sample t-test and analysis of variance for continuous variables were used to establish the relationship between impression errors and independent variables and for hypothesis testing on the relationship between impression quality and the independent variables. This was followed by ordinal logistic regression to quantify the strength of statistically significant associations between the impression errors and specific independent variables, and impression quality and the independent variables at a 95% confidence level.

3. Results

Although the sample size of 248 impressions was achieved, only 234 corresponding clinician details were available, translating to a response rate of 94.4%. Clinician experience ranged between 1 and 45 years with a median of 13.5 years, a mean of 8.39±11.96 years and the majority being GPs 189 (80.8%) while restorative dentists and other specialists were 27 (11.5%) and 18 (7.7%), respectively. Non-aqueous rubber elastomers formed the bulk of impressions, 229 (97.9%), with the rest being alginate, while the commonest impression technique employed was dual viscosity, 177 (75.6%), as compared to the monophase technique, 57 (24.4%). The impression trays used included stock metal, 141 (60.3%), stock plastic, 80 (34.2%) and custom trays, 13 (5.5%). Porcelain-fused-to-metal (PFM) crowns were the most prescribed laboratory work, 72 (30.8%), followed by all-ceramic crowns, 50 (21.4%), and PFM fixed partial dentures, 48 (20.5%).

Impression quality was good in 58 (24.8%), fair in 87 (37.2%) and poor in 89 (38.0%) impressions. Considering individual types of errors, 174 (74.5%) impressions had bubbles/ voids, 124 (53%) had tears and 101 (43.2%) had poor clarity of margins. There was a similar distribution pattern for mean clinician experience and clarity of margin preparations, and mean clinician experience and impression quality. The mean experience of clinicians who produced impression margins with good clarity was 18.4±12.4 years, fair clarity was 18.2±11.3 years, and poor clarity was 18.6±12.4 years. The mean experience of clinicians who made good quality impressions was 17.6±12.1 years, fair impressions was 18±11.8 years, and poor impressions were 19.2±12.1 years.

There was an association between the clarity of margins and the clinician specialty, (Fisher's exact = 9.372, p=0.047) (Table 1). An association was also noted between impression technique and impression quality, (Pearson's χ^2 (2) = 6.385, p=0.041) (Table 2). There was no association between clinician experience and the outcome variable (Table 3).

It was evident that restorative specialists were less likely to make impressions with poor margins, with the estimated odds of 1, 95% CI 0.15, 0.83, Wald χ^2 (1) = 5.71, p=0.02. In comparison to restorative specialists, the estimated odds of other specialists making impressions with poor margins was 5.71, 95% CI 1.55, 21.06, Wald χ^2 (1) = 5.24, p=0.009. In comparison to restorative specialists, estimated odds of GPs making impressions with poor margins was 2.19, 95% CI 0.88, 5.43, but the difference was not statistically significant, Wald χ^2 (1) = 2.86, p=0.09 (Table 4). It was also evident that the dual-phase technique was less likely to result in poor impressions, with estimated odds of 1, 95% CI 0.41, 0.75, Wald χ^2 (1) = 14.27, p=0.0002. In comparison to the dual-phase technique, the estimated odds of the Monophase/ Single Viscosity impression technique resulting in a poor-quality impression was 1.52, 95% CI 0.83, 2.78, but the difference was not statistically significant, Wald χ^2 = 1.52, p = 0.18 (Table 4).

Table 1. Univariate analysis of categorical independent variables in relation to categories of impression errors

Variable	Impressions, n (%)					
	Clarity of margin preparations				Fisher's (p value)	χ^2 (p value)
Clinician specialty	**Total**	**Good**	**Fair**	**Poor**		
General Practitioners	189 (80.8)	33 (73.3)	74 (84.1)	82 (81.2)		
Restorative Dentists	27 (11.5)	8 (20.0)	11 (12.5)	7 (6.9)	9.372, **(0.047)**	
Other Specialists	18 (7.7)	3 (6.7)	3 (3.4)	12 (11.9)		
Impression material						
Irreversible hydrocolloid	5 (2.1)	0	3 (3.4)	2 (2.0)	1.242 (0.613)	
Rubber elastomers	229 (97.9)	45 (100)	85 (96.6)	99 (98.0)		
Impression technique						
Monophase viscosity	57 (24.4)	9 (20.0)	22 (25.0)	26 (25.7)		0.589 (0.797)
Dual viscosity	177 (75.6)	36 (80.0)	66 (75.0)	75 (74.3)		
Impression tray						
Stock (Metal)	141 (60.3)	27 (60.0)	45 (51.1)	69 (68.3)		
Stock (Plastic)	80 (34.2)	16 (35.6)	36 (40.9)	28 (27.7)	6.111 (0.183)	
Custom tray	13 (5.5)	2 (4.4)	7 (8.0)	4 (4.0)		
	Tears on impressions					
Clinician specialty	**n (%)**	**Yes**	**No**			
General Practitioners	189 (80.8)	98 (79.0)	91 (82.8)			
Restorative Dentists	27 (11.5)	12 (9.7)	15 (13.6)			5.330 (0.071)
Other Specialists	18 (7.7)	14 (11.3)	4 (3.6)			
Impression material						
Irreversible hydrocolloid	5 (2.1)	2 (1.6)	3 (2.7)		0.018 (0.668)	
Rubber elastomers	229 (97.9)	122 (98.4)	107 (97.3)			
Impression technique						
Monophase viscosity	57 (24.4)	32 (25.8)	25 (22.7)			0.300 (0.648)
Dual viscosity	177 (75.6)	92 (74.2)	85 (77.3)			
Impression tray						
Stock (Metal)	141 (60.3)	80 (64.5)	61 (55.5)			
Stock (Plastic)	80 (34.2)	35 (28.2)	45 (40.9)			4.913 (0.098)
Custom tray	13 (5.5)	9 (7.3)	4 (3.6)			
	Bubbles or voids					
Clinician specialty	**n (%)**	**Yes**	**No**			
General Practitioners	189 (80.8)	143 (83.1)	44 (74.6)			
Restorative Dentists	27 (11.5)	18 (10.5)	8 (13.6)		2.639 (0.266)	
Other Specialists	18 (7.7)	11 (6.4)	7 (11.8)			
Impression material						
Irreversible hydrocolloid	5 (2.1)	5 (2.9)	0		0.649 (0.420)	
Rubber elastomers	229 (97.9)	167 (97.1)	59 (100)			
Impression technique						
Monophase viscosity	57 (24.4)	47 (27.3)	10 (16.9)			2.545 (0.119)
Dual viscosity	177 (75.6)	125 (72.7)	49 (83.1)			
Impression tray						
Stock (Metal)	141 (60.3)	105 (61.0)	35 (59.3)			
Stock (Plastic)	80 (34.2)	56 (32.6)	22 (37.3)		0.857 (0.672)	
Custom tray	13 (5.5)	11 (6.4)	2 (3.4)			

Univariate analysis was done with Pearson's χ^2 and Fisher's exact test. n = 234. Bold indicates p < 0.05

Table 2. Univariate analysis of categorical independent variables in relation to categories of impression quality

Variable	Impressions, n (%)					
		Quality of Impressions			Fisher's (p value)	χ^2 (p value)
Clinician specialty	n (%)	Good	Fair	Poor		
General Practitioners	189 (80.8)	49 (84.5)	70 (80.5)	70 (78.7)		
Restorative Dentists	27 (11.5)	7 (12.1)	9 (10.3)	11 (12.3)	2.182 (0.724)	
Other Specialists	18 (7.7)	2 (3.4)	8 (9.2)	8 (9.0)		
Impression material						
Irreversible hydrocolloid	5 (2.1)	0	1 (1.1)	4 (4.5)	3.044 (0.257)	
Rubber elastomers	229 (97.9)	58 (100)	86 (98.9)	85 (95.5)		
Impression technique						
Monophase viscosity	57 (24.4)	7 (12.1)	24 (27.6)	26 (29.2)		6.385 **(0.041)**
Dual viscosity	177 (75.6)	51 (87.9)	63 (22.4)	63 (70.8)		
Impression tray						
Stock (Metal)	141 (60.3)	29 (50)	54 (62.1)	58 (65.2)		
Stock (Plastic)	80 (34.2)	27 (46.6)	28 (32.2)	25 (28.1)	5.562 (0.232)	
Custom Tray	13 (5.5)	2 (3.4)	5 (5.7)	6 (6.7)		

Univariate analysis was done with Pearson's χ^2 and Fisher's exact test. n = 234. Bold indicates $p < 0.05$

Table 3. Univariate analysis of continuous independent variables in relation to categories of impression errors and impression quality

Variable: Clinician experience (years) and, Impression errors and Impression quality	Impressions, n (%)	Mean	SD	Lower, Upper	*F* (p value)	*t* (p value)
Bubbles/ Voids						
Yes	174 (74.5)	17.5	11.5	-6.6, 0.4		1.743 (0.083)
No	60 (25.5)	20.6	12.6			
Tears on impressions						
Yes	124 (53.0)	19.2	11.8	-1.3, 4.8		1.115 (0.266)
No	110 (47.0)	17.5	12.1			
Clarity of margins						
Good	45 (19.2)	18.4	12.3	14.7, 22.1		
Fair	88 (37.6)	18.2	11.3	15.8, 20.6	0.025 (0.975)	
Poor	101 (43.2)	18.6	12.4	16.1, 21.0		
Impression quality						
Good	58 (24.8)	17.6	12.1	14.4, 20.8		
Fair	87 (37.2)	18.0	11.8	15.5, 20.4	0.388 (0.679)	
Poor	89 (38.0)	19.2	12.1	16.7, 21.8		

Univariate analysis was done with independent sample t-test and analysis of variance. n = 234. Bold indicates $p < 0.05$

Table 4. Multivariate analysis predicting association between independent variables and clarity of margins and impression quality (dependent variable)

Clinician specialty	Clarity of margins		β Estimate	Exp (β) OR	Wald χ^2	p-value	95% Wald CI for Exp (β)
	Fair/Good	*Poor*					
Restorative specialist (Referent)	20	7	-1.05	1	5.71	**0.02**	(0.15, 0.83)
GP	107	82	0.78	2.19	2.86	0.09	(0.88, 5.43)
Other specialist	6	12	1.74	5.71	5.24	**0.009**	(1.55, 21.06)
Impression technique	**Impression quality**						
	Fair/Good	*Poor*					
Dual phase (Referent)	114	63	-0.59	1	14.27	**0.0002**	(0.41, 0.75)
Monophase	31	26	0.42	1.52	1.83	0.18	(0.83, 2.78)

n = 234. Bold indicates $p < 0.05$. OR, odds ratio

4. Discussion

This study aimed to establish the factors that influence the quality of final impressions for FDP. Independent variables that were considered were clinician socio-demographics, type of impression material, type of impression technique and type of impression tray. The primary outcome was the impression quality as described by the type and extent of errors. The majority of impressions were found to have at least one detectable error, as has been observed in other studies [4,6, 8,15]. The causes of errors evaluated included defects in material polymerization, lack of retention to tray, crucial areas beyond tray borders, heavy body material exposure through the wash material, inadequate union of different consistencies of materials, and embedded retraction cords, all leading to air bubbles, voids or tears along the margins and the rest of the impression. Unlike this study which assessed defects macroscopically, Samet *et al.* [4] inspected finish lines and margin areas using loops at magnification of x2.5. Nonetheless, their findings on the occurrence of bubbles/voids or tears were similar to the present study and to that by Rau *et al.* [6]. Despite the high presence of errors, it remains noteworthy that most of the impressions were deemed acceptable, similar to the referent studies. It is generally agreed that impression errors can be mitigated by ensuring proper manipulation of the impression materials according to the manufacturer's recommendations, ensuring a homogenous mixture, use of an appropriate impression tray, soft tissue retraction, drying the tooth preparation area, appropriately syringing the impression material to ensure no air gets trapped and giving the impression material time to set completely before withdrawing it from the mouth [11,12]. If bleeding from the gingival tissue is excessive, the use of retraction pastes containing ferric sulphate and compression caps to apply pressure may serve as an effective alternative to liquid or gel haemostatics. If bleeding cannot be controlled, the final impression may be delayed by a week following the usage of a chlorhexidine mouth rinse [24].

In this study, it is remarkable that nearly half of the preparation margin finish lines were of poor clarity similar to other reports [6]. A poor margin finish line record may be a result of the failures of materials and techniques such as insufficient flow of the material due to incorrect choice of viscosity, inadequate amount of impression material, tearing of the impression material, inadequate gingival tissue retraction or unfavourable sulcular width of less than 0.2mm [11,12,25]. However, it is also likely that the preparations were not properly defined so that even if these material and technique issues were to be addressed, the clarity would remain poor. Indeed, a significant difference has been shown between the accuracy of margins and the quality of impressions supervised by prosthodontists and GPs, with work from the former being better [13].

Findings from the present study corroborate this presumably by indicating that in comparison to restorative specialists, GPs and other specialists were more likely to produce impressions with poor margins, not due to the impression technique but arising from the quality of the preparation itself. While this difference was statistically significant between restorative and other specialists, it was not between restorative specialists and GPs. It is noteworthy that the lack of statistical significance may be explained by the markedly higher number of GPs in the study as compared to the specialists who were very few in the country during the period of study. Further validation is provided by the finding that the clinician socio-demographics were not found to affect the overall impression quality score because this was determined by several aspects including clarity of margins, homogeneity of the impression material, presence of bubbles, voids and tears. Moreover, this could be influenced by additional variables, including good case selection, appropriate treatment planning and execution through proper patient preparation, tray selection, impression making, impression handling and processing.

There was no correlation between the quality of the impression and the type of tray used. Generally, there was higher usage of stock trays similar to findings from other studies, although Samet *et al.* [4] and Zu Saifudin *et al.* [9] reported plastic stock trays, in addition to dual-arch custom impression trays [4], while the present study observed mostly metal stock trays. Contrarily, another study reported greater usage of dual arch custom trays [15]. The widespread use of stock trays in this study may be due to their low cost or lack of knowledge among clinicians about their shortcomings. Trays should be as rigid as possible to resist deformation from pressure both during the impression-making process and after removal from the mouth. Materials of higher viscosity may result in an increase in flexure of the trays and marginal opening of restorations hence the recommendation of rigid custom trays [14,15,26]. However, stock metal trays are sterilisable and reusable which is a common practice in LMIC due to economic considerations [9]. In this study, there was also no correlation between impression quality and the type of impression material used. The majority of the impressions were recorded using non-aqueous rubber elastomers while only 2% used alginate. It is noteworthy that a previous survey by Kisumbi *et al.* in 2017 [11] on the selection of impression materials and techniques among dentists in Kenya found that alginate was used by nearly 6% of the clinicians for impressions for FDP. The dimensional instability of alginate impression material limits its usage, thus non-aqueous rubber elastomers are preferred for their reproduction of fine details, minimal dimensional change after setting, moderately short working and setting time and excellent recovery from deformation on withdrawal [11].

There was a positive correlation between impression technique and impression quality. A higher percentage of acceptable impressions (good or fair) was recorded using the dual phase than the monophase technique, with a statistically significant prediction that the dual viscosity technique was less likely to result in poor-quality impressions. Ghahremanloo *et al.* [27] in a study to compare the accuracy of dental implant impressions obtained by a combination of different impression techniques and viscosities of polyvinyl siloxane established that the monophase technique had a high incidence of voids and tears. However, while the monophase technique was more likely to result in poor-quality impressions in comparison to the dual viscosity technique, the difference was not statistically significant. The monophase technique has been found to result in a higher incidence of voids and tears even in custom trays, often attributed to failure to syringe the material properly over critical areas [22, 27].

This study is not without limitations. Impressions were examined immediately after they were received in the laboratory and prior to any processing; nonetheless, we do not overlook the fact that transportation coupled with weather conditions may affect dimensions. However, these are the same conditions under which the impressions are routinely handled, and restorations produced thus unlikely to alter our findings. We also acknowledge that we limited evaluation to macroscopically visible errors only meaning that microscopic ones were missed. We cannot exclude an effect but think it unlikely that it would change our results when we consider that impressions and resultant dies, models and restorations are routinely scrutinized and processed under normal vision. Finally, while it is commendable that most impressions were non-aqueous rubber elastomers, information on the actual type of the elastomer and impression technique could not be obtained merely by looking at the impression. It was therefore assumed that a single colour was a monophase technique while two colours denoted a dual-phase technique, but we could not further distinguish between single- or two-step techniques. We recommend that a similar study be conducted within the clinics so that this information may be obtained before the impressions are sent to the laboratory.

6. Conclusion

Within the limitations of this study, we conclude that while the majority of the impressions were deemed acceptable, many of them had at least one error even if not in the critical areas. Metal custom trays, non-aqueous rubber elastomers and dual viscosity impression techniques were most frequently used. PFM crowns and fixed partial dentures and all-ceramic crowns were often prescribed and mostly by GPs. Clarity of preparation finish line margins was more likely to be of good quality when produced by restorative specialists while impressions were more likely to be of good quality if recorded using the dual viscosity technique. Impression quality was not influenced by the type of material and type of the impression tray. The snapshot nature of cross-sectional studies cannot be overlooked therefore it is impossible to make causal inferences from this study. However, the study area and population are a good representative sample of the practice of fixed prosthodontics in our setting, thus making the generalizability of the findings acceptable.

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List of abbreviations

FDP – Fixed dental prostheses
GP – General practitioner
LMIC – Low- and middle-income countries
PFM – Porcelain-fused to-metal

Declarations

Availability of data and materials

The datasets used and/or analysed during the current study are not publicly available to maintain participant privacy and confidentiality requirements but are available from the corresponding author on reasonable request.

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