Effect of Microwave and Sodium Hypochlorite Disinfection of Alginate Impressions on Dimensional Accuracy of Such Impressions

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ABSTRACT

Objective: This study investigated the impact of disinfection methods, specifically sodium hypochlorite and microwave irradiation, on the dimensional accuracy of alginate impressions.

Methods: This was a randomized comparative clinical study. A purposive sampling technique of consecutive individuals was employed for the study. The maxillary impression of employed participants was made and randomly assigned to either of two groups (microwave irradiation vs sodium hypochlorite disinfection) by simple random technique. Two impressions were made for each participant. The first impression was poured with dental stone to make a stone cast without disinfection, the second impression made, was disinfected either using 0.5% sodium hypochlorite disinfectant or microwave irradiation for 2 minutes, before a stone cast was made from this impression. The dimensional accuracy of each cast was assessed by measuring the bucco-palatal width of the two maxillary first molars using a handheld digital caliper (with an accuracy of 0.01mm) and getting the average of the two measurements.

Result: A total of 120 upper impressions were made using alginate impression material for 60 participants. The buccolingual dimension of the first molars ranged from 4.32 to 6.10mm before and after sterilization. The mean buccolingual dimension before sterilization was 5.30±0.39 and the mean buccolingual dimension after disinfection was 5.30±0.42, which was not statistically significant (p=0.78). Disinfection with sodium hypochlorite (p=0.94) and microwave irradiation (p=0.74) on the dimensional accuracy of impressions was not statistically significant

Conclusion: There were no significant dimensional inaccuracies in casts obtained from alginate impressions disinfected with sodium hypochlorite or microwave irradiation compared to those obtained from alginate impressions without disinfection

Keywords: Microwave irradiation, Sodium hypochlorite, disinfection, Dimensional accuracy, Alginate

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INTRODUCTION

An accurate impression and a stable and accurate die material can lead to accurate, precise, undistorted models and prostheses.[1] In dentistry, several impression materials have properties including accuracy, elastic recovery, dimensional stability, flow, flexibility, workability, hydrophilicity, a long shelf life, patient comfort and economics.[2] Alginate impression is the most used impression material in dentistry since it is easy to manipulate, does not require sophisticated equipment and is economical.[2,3]

Typically, impressions are rinsed under running water to reduce the microbial load, but this alone does not eliminate the infection potential of the impression.[4,5] Hence, alginate impressions when made need to be disinfected to prevent cross infection, which can cause alginate to either absorb or lose water, leading to instability[6,7] To minimize dimensional distortions, studies have recommended immediate pouring or pouring within minutes without wrapping in a wet towel.[8,9,10]

An ideal disinfectant for impressions must meet two key criteria: effectively reduce microbial load and preserve the dimensional accuracy and surface details of the impression.[11] Selecting the right disinfectant ensures impression integrity and successful prosthetic outcomes. The dimensional accuracy of impression materials is directly dependent on elastic recovery of the material, shrinkage of the impression material, evaporation of volatile components from the impression material or expansion of gypsum products used to pour the impression.[12]

An investigation into the influence of 1% sodium hypochlorite spray on alginate impression material revealed negligible effects on dimensional accuracy and surface texture.[13] However, alginate impressions immersed in 0.5% sodium hypochlorite for 15 minutes showed slight dimensional changes.[14] In a systematic review of 50 studies, it was recommended that alginate impression should be disinfected with 0.5% sodium hypochlorite using the spray disinfection method for 10 minutes.[15] In another study by Bustos et al., it was reported that effective disinfection with minimal changes in dimensional stability and surface integrity with alginate impression material in 0.5% sodium hypochlorite for 5 minutes rather than 10 minutes.[16] There appear to be limited number of studies on the effect of microwave on the dimensional accuracy of alginate impressions, however, Choi et al. reported the effectiveness of microwave in disinfecting vinyl polysiloxane impression without adversely affecting their physical properties especially when combined with hydrogen peroxide.[17] However, Al Kheraif reported a significant increase in the surface roughness of vinyl polysiloxane after microwave disinfection.[18] Locally, there is a noticeable scarcity of research investigating the impact of microwave and sodium hypochlorite disinfection on the dimensional accuracy of alginate impressions, highlighting a significant knowledge gap in this area. This study therefore aimed to investigate the impact of disinfection methods, specifically sodium hypochlorite and microwave irradiation, on the dimensional accuracy of alginate impressions.

METHODOLOGY

The study was conducted at the Prosthodontics clinic of the University of Benin Teaching Hospital in Benin City, Edo State, Nigeria which serves as the major referral centre for residents in the state and some adjoining cities. Before the study commenced, ethical approval was sought from the Health Research Ethics Committee of the University of Benin Teaching Hospital, Oral informed consent was obtained from each participant before participation in the study. The study population consisted of consenting fully or partially dentate individuals attending the clinic, with no dental prostheses or restoration. The sample size was calculated using the Computer Program for Epidemiological Analysis.[19] With the formula as below.

$$n = \frac{(Z\partial + Z\beta)2 \times 2 \times \sigma 2}{d^2}$$

where

$Z_{\alpha/2}$ is the critical value of the Normal distribution at α/2 (for a confidence level of 95%, α is 0.05 and the critical value is 1.96),
Z_{β} is the critical value of the Normal distribution at β (for a power of 80%, β is 0.2 and the critical value is 0.84),
σ^2 is the population variance, would be 1000.
d is the difference you would like to detect and would be using 25.01 mean difference from a previous study.[20]

$$n = \frac{(1.96 + 0.84)^2 \times 2 \times 1000}{25.01^2}$$

n = 25.1 which is approximately 25with 10% attrition rate it will be 27.5 approximately 28 per group making the sample size 56.

The inclusion criteria were partially and fully dentate persons with no dental restorations or prosthesis who had first upper molars. The participants were employed using a purposive sampling technique and randomly assigned to either the microwave irradiation or sodium hypochlorite disinfection groups. A bag of pre-numbered cards (1 to 56) was presented to the participants to pick a number. All participants who picked even numbers were assigned to the microwave irradiation group, while those who picked odd numbers were assigned to the hypochlorite disinfection group.

Two upper alginate impressions were made for each participant using alginate impression (Hygedent, China)[R]. The first impression was poured with dental stone to make a stone cast without disinfection, while the second impression made, was disinfected using either 0.5% sodium hypochlorite (Jik, Nigeria) disinfectant or microwave irradiation (500 watt) for 2 minutes, before a stone cast was poured from it. The stone cast was inspected for any structural defects such as cracks and chipping off, if any, it was discarded, and the process repeated. If there was no structural defect, the stone cast was evaluated for dimensional accuracy.

The evaluation of dimensional accuracy in each stone cast was by measuring the bucco-palatal width of the two maxillary first molars using a handheld digital calliper (with an accuracy of 0.01mm) using a procedure from a previous study.[21] Both tips of the digital calliper were placed at the gingival margin on the buccal and palatal aspect of the first molar tooth on the stone cast, and a linear measurement was taken of the stone cast by one trained evaluator (OA). Two fixed points on the stone cast were used preferably the Bucco palatal width of the first permanent molar (the greatest curvature). An average measurement of both the right and left upper first molar was recorded.

All measurements taken were entered into a personal computer. The data was analysed using IBM SPSS 26.0. Descriptive statistics was done using mean and standard deviation. An Independent Sample t-test was used to compare the means before and after sterilisation. To account for any pre-existing differences in dimensional accuracy, an Analysis of Covariance (ANCOVA) was employed, which allowed for the comparison of the mean dimensional accuracy values between the two disinfection methods, while controlling for the initial dimensional accuracy measurements. P was set at≤ 0.05. The results were presented as tables.

RESULT

The study involved a total of 120 upper impressions made using alginate impression material for 60 participants. The buccopalatal dimension of the first molars was measured before and after disinfection, and the results showed a range of 4.32 to 6.10mm. The mean buccopalatal dimension of the first molar before disinfection was 5.30mm with a standard deviation of 0.39mm. After disinfection, the mean buccopalatal dimension remained consistent at 5.30mm with a standard deviation of 0.42mm. A paired t-test was conducted to compare the mean buccopalatal dimension before and after disinfection, and the results showed no statistically significant difference (p=0.78).[Table 1]

Table 1: Mean disinfection before and after sterilization

Mean	N (mm)	P
Before disinfection	5.31±0.39	0.78
After disinfection	5.30±0.42	

The effect of sodium hypochlorite disinfection on the dimensional accuracy of the cast was also evaluated. The results showed that the mean buccopalatal dimension of the first molar before disinfection was 5.29mm with a standard deviation of 0.40mm, and after disinfection, it was 5.29mm with a standard deviation of 0.43mm. A paired t-test was conducted to compare the mean buccolingual dimension before and after disinfection, and the results showed no statistically significant difference (p=0.81). [Table 2]

Table 2: Effect of hypochlorite disinfection on dimensional accuracy

Sterilization	Mean (mm)	P value
Before sterilization	5.28±0.39	0.94
After sterilization	5.29±0.44	

N=30

Similarly, the effect of microwave irradiation on the dimensional accuracy of the cast was evaluated. The results showed that the mean buccopalatal dimension of the first molar before disinfection was 5.31mm with a standard deviation of 0.39mm, and after disinfection, it was 5.31mm with a standard deviation of 0.41mm. A paired t-test was conducted to compare the mean buccolingual dimension before and after disinfection, and the results showed no statistically significant difference (p=0.74).[Table 3]

Table 3: Effect of microwave irradiation on dimensional accuracy

Sterilization	Mean (mm)	P value
Before sterilization	5.34±0.39	0.74
After sterilization	5.30±0.41	
		N=30

A comparison of the buccolingual dimension of the first molar casts between the microwave irradiation and hypochlorite disinfection groups was also conducted. The results showed that the mean buccopalatal dimension of the first molar cast was 5.30mm with a standard deviation of 0.41mm in the microwave irradiation group, and 5.29mm with a standard deviation of 0.44mm in the hypochlorite disinfection group. An independent t-test was conducted to compare the mean buccopalatal dimension between the two groups, and the results showed no statistically significant difference (p=0.67). [Table 4]

Table 4: Comparison of means after disinfection.

Sterilization	Mean (mm)	P value
Microwave irradiation	5.30±0.41	0.67
Hypochlorite	5.29±0.44	

Finally, a multivariate analysis was conducted to adjust for pre-disinfection dimensional accuracy and compare the dimensional accuracy between the microwave irradiation and hypochlorite disinfection groups. The results showed that after adjusting for pre-disinfection dimensional accuracy, there was no statistically significant difference in dimensional accuracy between the two groups (p=0.65). The buccopalatal dimension of the first molar cast was found to be similar between the microwave irradiation and hypochlorite disinfection groups, with a mean difference of 0.01mm and a 95% confidence interval of -0.11 to 0.13mm. [Table 5]

Table 5: Analysis of variance (ANCOVA)

Source	Mean sq	F	Sig
Corrected model	1.996	17.435	0.000
Intercept	0.903	7.883	0.007
Before disinfection	3.990	34.849	0.000
Disinfection	0.009	0.078	0.000
Error	0.114		

DISCUSSION

The buccopalatal dimension of the first molars was found to be highly consistent, measuring 5.30mm on average, with no significant difference observed before and after disinfection. Although, the standard deviation slightly increased after disinfection (0.42mm vs 0.39mm), the difference was not statistically significant. This suggests that the disinfection process, whether employing microwave irradiation or 0.5% sodium hypochlorite, did not substantially affect the accuracy of the impressions. Notably, the buccopalatal dimension of the first molars remained unchanged; indicating that the impressions maintained their precision throughout the disinfection process.

Although the dimensional change observed was not statistically significant, it is still possible that it could have a practical impact on the accuracy of fit of certain restorations, particularly those that require high precision, such as implants or precision attachments.

This study had a limitation in that the participants were not used as their own controls. A follow-up study where participants serve as their own controls would be beneficial to determine if the results would be consistent, allowing for a more accurate comparison and a deeper understanding of the outcomes.

These results are consistent with existing literature, demonstrating that disinfection with 0.5% sodium hypochlorite has no statistical effect on the mean dimensional accuracy of a model. A study by Rentzia et al.,[22] investigated the impact of disinfecting solutions (0.5% sodium hypochlorite and Cidex OPA) on the dimensional accuracy and surface quality of an irreversible hydrocolloid. Despite variations in immersion disinfection times, they found no significant effect of the disinfectant solution on the dimensions measured between different reference points.[22] Similarly, studies also reported comparable findings[23,24,25], further supporting the notion that disinfection with 0.5% sodium hypochlorite does not significantly affect dimensional accuracy.

This study found that microwave irradiation had no statistically significant effect on the dimensional accuracy of the model after disinfection (p=0.74). This result corroborates the findings of Khalid et al., who demonstrated that microwave disinfection maintained the dimensional accuracy of gypsum casts throughout seven disinfecting cycles, when compared to repeated chemical disinfection.[26] The dimensional accuracy of dental models and casts

remains unaffected by microwave irradiation disinfection, as evidenced by the consistent results of these studies, regardless of the number of disinfection procedures.

Results of this study demonstrated that both hypochlorite disinfection and microwave irradiation disinfection methods preserved the dimensional accuracy of the casts, with no statistically significant alterations observed. This suggests that these disinfection methods can be employed without compromising the accuracy of the impressions and casts. The high p-values (0.94 and 0.74) further support this conclusion, implying that any minor differences observed in dimensional accuracy are likely attributable to chance rather than the effect of the disinfection methods. Therefore, these findings provide robust evidence that the disinfection protocols can be implemented without adversely affecting the quality of impressions and casts.

While the study provides valuable insights into the effects of disinfection on buccolingual dimension, it is essential to acknowledge its limitations. This study had a narrow scope, limiting its evaluation to the buccopalatal dimension of the first molars, and did not explore other critical aspects of impression and cast accuracy. As a result, there is a need for further research to investigate the effects of disinfection on other dimensions, such as mesiodistal and occlusogingival dimensions, as well as other quality parameters, including surface detail reproduction, to provide a more comprehensive understanding of the impact of disinfection on impression and cast accuracy. In addition, the present study only investigated the effects of a 2-minute disinfection protocol using sodium hypochlorite and microwave irradiation and found no statistically significant changes in dimensional accuracy. However, the impact of longer disinfection times on the dimensional accuracy of alginate impressions remains unknown. Future studies could explore the effects of extended disinfection durations, such as 5, 10, or 15 minutes, to provide a more comprehensive understanding of the disinfection process and its potential effects on impression accuracy, thereby shedding light on the optimal disinfection protocol for clinical practice.

The findings of this study could influence our dependency on sodium hypochlorite on disinfecting of alginate impression, which are a widely available and affordable option. The use of microwave irradiation as an alternative disinfection method could prove to be a cost-effective solution in the long run. It also highlights the potential of microwave irradiation as a viable alternative to traditional chemical disinfection methods, such as sodium hypochlorite.

CONCLUSION

The study revealed that there was no significant change in the dimensional accuracy of dental casts after disinfection of alginate impressions using either microwave irradiation or sodium hypochlorite. This suggests that both methods are effective in preserving the accuracy of the impression, which is crucial for the fabrication of precise dental restorations.

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Conflict of interest
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