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RESEARCH ARTICLE

PHOTO-ANALYSIS EVALUATION FOR DIMENSIONAL ACCURACY OF DIFFERENT IMPRESSION MATERIALS FOR COMPLETELY EDENTULOUS MAXILLARY RIDGES (CLINICAL STUDY)

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Abstract

Background: In complete denture prosthodontics, an edentulous arch precise reproduction through the secondary impression is necessary for denture retention and esthetics. Variance in the supporting oral structures' nature and quality demands utilizing various accurate border molding and ultimate impression materials to attain successful prosthesis.

Objectives: Tophoto-analytically evaluate and compare the dimensional accuracy of four dissimilar final maxillary completely edentulous impressions fabricated from two dissimilar border molding and secondary impression materials.

Materials and Methods: Ten completely edentulous patients were nominated rendering to inclusion criteria and received complete dentures. For each patient, four dissimilar secondary maxillary impressions were constructed and divided into four groups owing to the border molding and impression materials utilized. All impressions were transferred into type IV dental stone, and casts were all snapped through a digital camera with fixed and repeatable stipulations. All photos attained were presented into computer software. Two dimensions were possessed for individual cast and compared.

Results: An insignificant difference was apparent among all groups concerning parameters as $P=0.06$ and angles as $P=0.053$. Data were collected, tabulated, and statistically investigated utilizing Statistical Package for Scientific Studies¹⁶®, Graph pad Prism, and Windows Excel.

Conclusion: However, recent elastomeric Putty and Medium rubber base impression materials almost possess equivalent means of dimensional accuracy in contrast with the conventional ones. But still, Greenstick compound and Zn/O Eugenol impression paste are insignificantly more dimensionally accurate in fabricating final impressions for completely edentulous patients.

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Introduction:-

In removable prosthodontics, complete denture success critically relies on the final impression phase and its exactness in recording the edentulous arch for guaranteeing the final prosthesis retention, support, stability, fit, and esthetics of the final prosthesis. Accurate capturing of the underlying tissues and structures' fine specifics is mandatory, which reveals the vital utilization of dimensionally stable impression materials. Although variance of the supporting oral tissues and structures in nature, texture, and quality is crucial, the diversity of impression materials and techniques is highly advantageous in attaining the finest outcomes for the delivered complete denture^(1,2).

The precision of the final master cast is established from the secondary impression and influenced by numerous factors such as type, accuracy, and technique of impression material together with the cast's materials. Furthermore, since the master cast's accurateness, consistency, and even thickness vastly relies on the special tray, hence it should fulfill particular requirements through time, such as high dimensional stability, not being permanently deformed, and firm adherence with the impression material principally on its elimination from patient's mouth. Accordingly, the usual application of a tray adhesive is crucial for both the impression material to tray adherence and the polymerization shrinkage equable dissemination through the material^(3,4).

Vestibule capturing is a significant demand in the complete denture's final impression, attained through border molding, which improves the custom tray adaptation near the vestibule for confirming appropriate flange extension and accompanied by impression construction for the edentulous arch. Diverse border molding and final impression materials have been employed for years. Although the modeling compound has been the habitually recommended border molding material, recently, polyether and polyvinylsiloxane have favorable additional elastic forms. There are plentiful compatible materials have been utilized in the edentulous arch final impression, including the metallic oxide paste, irreversible hydrocolloid, zinc oxide eugenol (Zn/O Eugenol), polyether, polysulfide, condensation, and additional silicones^(5,6).

Zn/O Eugenol impression paste is a mix of an irreparable nonelastic base and reactor pastes. The base paste comprises zinc oxide and acetate, a trace of water collected with olive and linseed oil. The reactor one embraces eugenol, rosin, accelerator, resinous balsam, color pigments, and fillers, such as kaolin and talc. Flowability, dimensional stability, precise soft tissue record, feasibility, and economical affordability are its remarkable merits. Conversely, due to its brittle nature and non-soft tissue displaceability, limiting stock tray employment, recording edentulous arches, and severe undercuts are major disadvantages. Moreover, its notable demerits are variable setting time with humidity and temperature, dropping-out disagreeable continual taste, superior adherence to the lip and cheeks' skin, and the triggering burning sensation in eugenol-sensitized patients. Consequently, despite the advancement of Zn/O Eugenol paste by providing an edentulous area wash impression, the light-bodied rubber base impression material is a pretty substitute owing to its limitations^(7,8).

There are diverse forms of elastomeric impression materials, such as condensation silicone used in recording edentulous arches and contain both base and accelerator. The hydroxy-terminated poly-dimethyl siloxane and fillers were expressible as a polymer and viscosity control is the base constituent. The accelerator comprises both tetraethyl silicate and tin octoate acting as a catalyst. Although being prone to shrinkage and instant pouring is demanded, its advanced dimensional accuracy and stability, supreme detail duplicability, exceptional elastic recovery, handled effortlessly, facility of numerous casts production from the single impression, agreeable odor, and taste are their rationale for being utilized in final impression construction^(1,9).

Lately, computerized tools for scientific image analysis have been clarified as remarkably beneficial in calibrating the diverse photographs' spatial and physical contents besides determining precise alterations available⁽¹⁰⁾. Although the complete denture's success is highly reliable in the final impression materials and techniques employed, the dimensional accuracy of the highly stable diverse impression and border molding materials utilized for capturing the underlying supporting tissues and structures' fine details is not digitally evaluated enough.

Accordingly, this study's objective was to photo-analytically evaluate and compare the dimensional accuracy of four diverse final maxillary completely edentulous impressions fabricated from two dissimilar border molding and secondary impression materials. It was hypothesized that the secondary impression fabricated from Zn/O and Eugenol impression material and Greenstick compound borders provides the highly accurate final impression for completely edentulous patients.

Materials and Methods:-

Materials:-

1. Self-Cure Acrylic-Resin (Acrostone; Acrostone dental factory - industrial zone -Salam city A.R.E-WHW Plastic, England).
2. Pink Wax (Cavex; Fustweg 5, 2031 CJ Haarlem, Holland, The Netherlands).
3. Adhesive Material Denture adhesive (COREGA; Adhesive Ultra Corega Cream; (gsk) GlaxoSmithKline Brazil Ltda., BRAZIL; CA).
4. Greenstick Compound (Pyrax Tracing Sticks; PyraxPolymars, 1142/2, Krishan Kunj, 7 Civil Lines, Roorkee-247667, (UK.) India).
5. Zn/O Eugenol Impression Material (Cavex; Fustweg 5, 2031 CJ Haarlem, Holland, The Netherlands).
6. Medium Rubber Base Impression Material (C- silicon rubber base impression material; ZhermackZetaplus S.p.A, Bovazecchino, 100, 45021 Badia Polesine (Rovigo) Italy).
7. Putty Rubber Base Impression Material (C- silicon rubber base impression material; ZhermackZetaplus S.p.A, Bovazecchino, 100, 45021 Badia Polesine (Rovigo) Italy).
8. Type IV Dental Stone (Type 4 model dental stone for models in a removable prosthesis; Elite Rock Stone-Zhermack Clinical, Italy).

Study Design:

Complete dentures were constructed for ten middle-aged (40-50) male completely edentulous patients. Four dissimilar secondary maxillary impressions were gained for every patient and divided into four groups owing to the type of border molding and impression materials utilized. All the impressions were appropriately boxed and poured into master casts then snapped through a digital camera with immovable and reiterated stipulations. The digital photos were then introduced into computer software (Digimizer® Software V. 4.3.1), and two dimensions were gathered for individual cast and then related.

Ethical Approval:

The existing study has been functional to the Ethics Code of the World Medical Association, next to the ethics detailed in the Declaration of Helsinki in 1975. This work has been allowable through the “Medical Research Ethical Committee of the National Research Centre, Cairo, Egypt” with convention number 03410224. Entire patients were updated with the present research’s practical stages and convened the printed consent.

Sample Size Calculation

The sample size was estimated employing former research as a reference⁽¹⁰⁾. Consequently, the minimally recognized sample size was 10 per group when the mean \pm standard deviation of retention after 1 month in Group I was 77.35 ± 1.54 , while the assessed mean difference by the other group was 1.5, once the power was 80 % and type I error possibility was 0.05. The Paired T-test was accomplished through P.S. power 3.1.6.

Patient’s Grouping:

This study comprised a total number of 10 patients in all groups. For each patient, four dissimilar secondary maxillary impressions were attained and divided into four groups owing to the border molding and impression materials utilized. Secondary impressions were fabricated in each group as follows;

1. **Group I** from Zn/O Eugenol impression material with Greenstick compound borders.
2. **Group II** from Zn/O Eugenol impression material with Putty borders.
3. **Group III** from the Medium rubber base impression material with Greenstick compound borders.
4. **Group IV** from the Medium rubber base impression material with Putty borders.

Inclusion and Exclusion Criteria:

The inclusion criteria comprised completely edentulous male patients aged 45-50 years with well-developed ridge, regular bone anatomy, firmly attached overlying mucosa, and Kennedy class I maxillary arch. Though smokers, uncooperative and non-systemically free patients as well as those with systemically immunosuppressive illnesses, Temporomandibular joint disorders, parafunctional habits, and a history of radiotherapy or chemotherapy were entirely excluded.

Methods:-

Special Tray Construction:

Four maxillary special trays with a spacer and a single mandibular one were constructed for each patient from self-cure acrylic resin and pink wax on their primary casts. Each tray was tried in its patient's mouth and borders were accurately accustomed to avoid sharp edges, ending up with a suitably adjusted special tray; as displayed in Figure (1).



Figure (1):- The maxillary acrylic resin special tray.

Border Molding and Secondary Impression Construction:

Every single patient had four dissimilar secondary maxillary impressions. Each patient's impressions were constructed on the same day and were divided into four Groups based on the type of border molding and impression materials utilized.

Zn/O Eugenol Impression Material:

Group I impressions were constructed by molding special tray borders with Greenstick compound, accompanied by employing the Zn/O Eugenol impression paste for the ultimate impression making which was mixed and left to set rendering to the manufacturer's directions; as revealed in Figure (2).

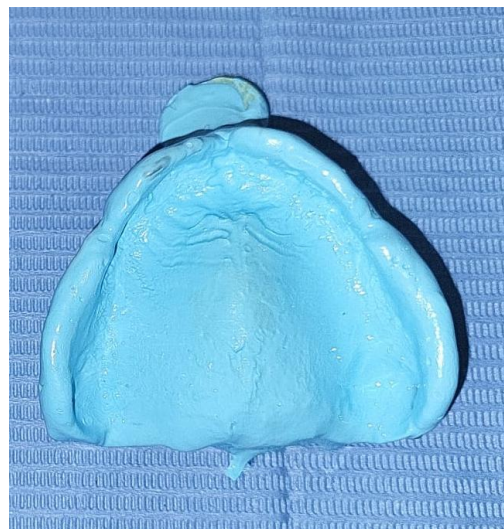


Figure (2):- Zn/O Eugenol impression with Greenstick compound borders.

Group II impressions were fabricated by employing the putty rubber base impression material for border molding successive to adding an adhesive material then followed by mingling and leaving Zn/O Eugenol paste to set owing to the manufacturer's guidelines for the terminal impression making; as presented in Figure (3).



Figure (3):- Zn/O Eugenol impression with Putty borders.

Medium Rubber Base Impression Material:

Group III impressions were created by molding special tray borders with Greenstick compound, accompanied by consuming the Medium rubber base material for the terminal impression fabrication, which was mixed and left to set rendering to the manufacturer's instructions; as displayed in Figure (4).



Figure (4):- Medium rubber base impression with Greenstick compound borders.

Group IV impressions were accomplished by utilizing the Putty rubber base impression material successive to adding an adhesive for special trays' border molding then accompanied by mingling and leaving the Medium rubber base material to set based on the manufacturer's regulations for the terminal impression fabrication; as presented in Figure (5).

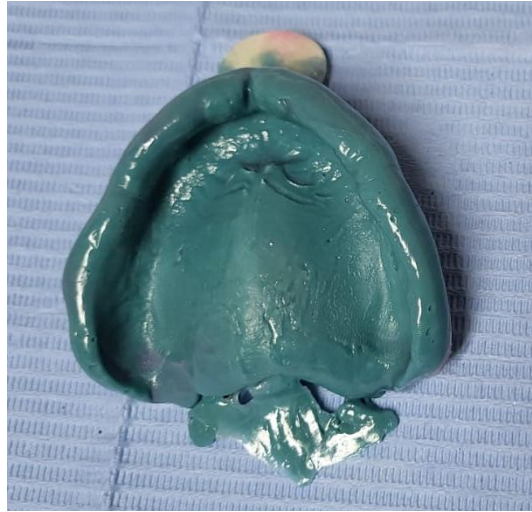


Figure (5):- Medium rubber base impression with Putty borders.

Master Cast Fabrication:

Boxing and pouring of all the attained impressions were carried out by utilizing type IV dental stone at an identical room temperature and humidity environment, appropriately tracking all the manufacturer's highlights in mixing, pouring, and setting the dental stone. Sequential to master cast pouring, dimensionally equivalent standardized bases were employed for cast settling, easing their comparison and avoiding any contrivance of bias throughout the study.

Casts Photography and Photo-Analysis:

Cast photography was eventuated by anticipating a stand-supported digital camera at an equivalent space and angle from all the gained casts with specified recurrent specifications; as demonstrated in Figure (6).



Figure (6):- Maxillary final photographed cast.

Photo-Analysis and Lines Assessment:

Successively assessments were applied for all casts in the form of line assessment. All digital photographs were presented into a computer Digimizer® Software V. 4.3.1. and two assessments were attained from every photographed cast through having a line lengthening from the anterior line angle of the standardized base to the contra-lateral hamular notch area and vice-versa, creating a three-sided triangle whose perimeter was calculated in pixels; as presented in Figures (7-10).

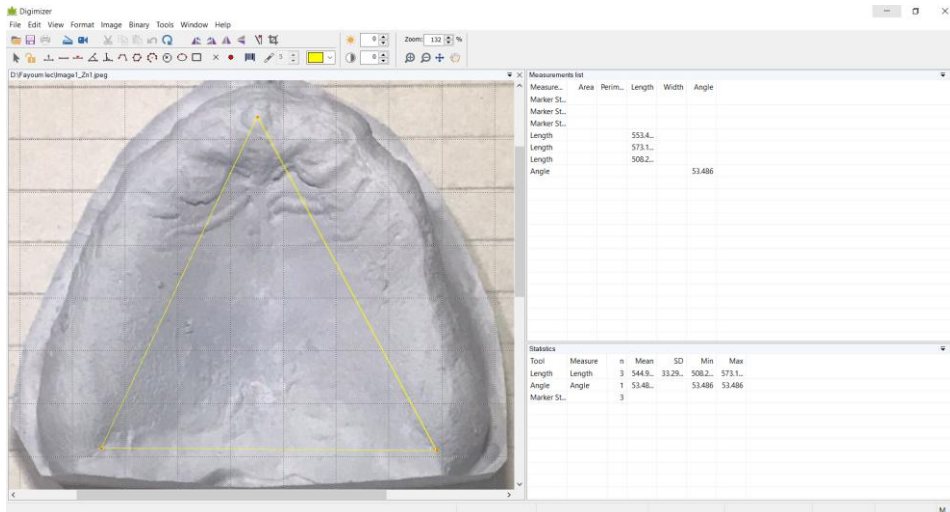


Figure (7):- Digimizer lines assessment of Zn/O Eugenol with Greenstick compound Photo-Analysis.

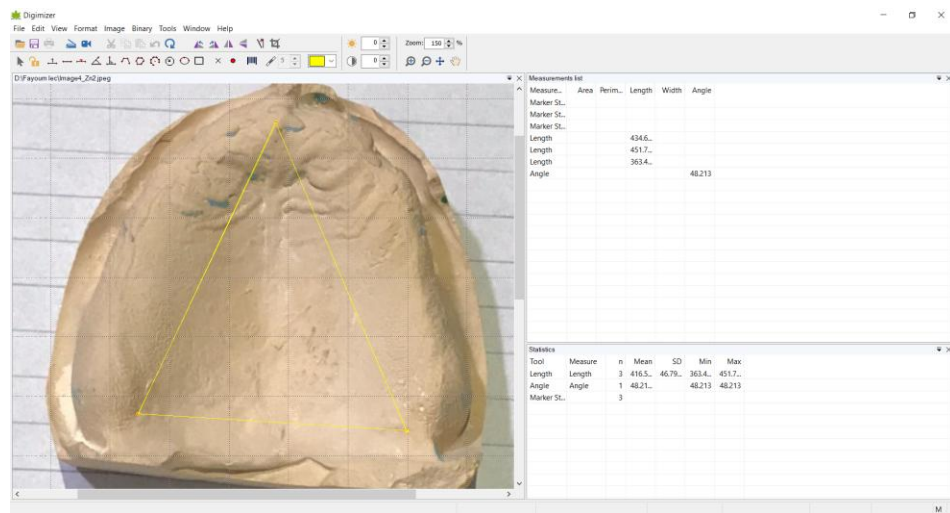


Figure (8):- Digimizer lines assessment of Zn/O Eugenol with Putty Photo-Analysis.

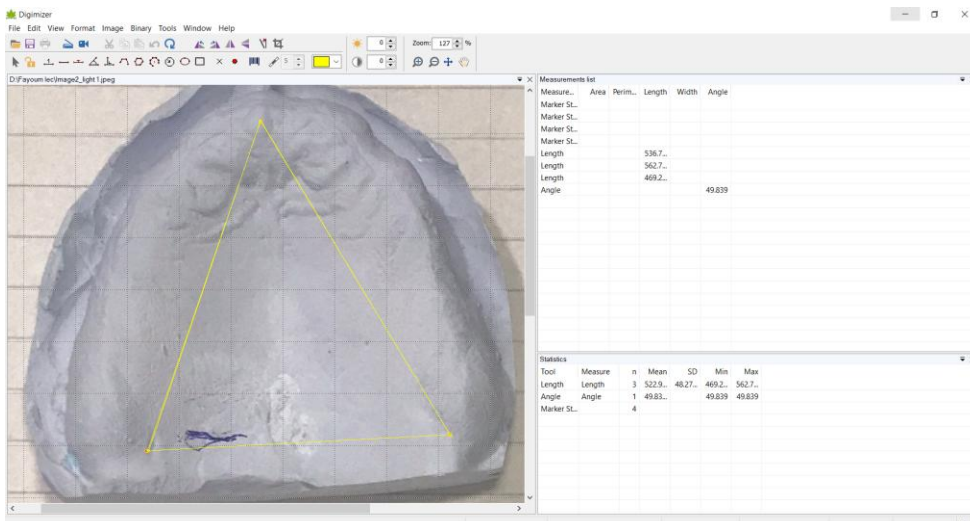


Figure (9):- Digimizer lines assessment of Medium with Greenstick compound Photo-Analysis.

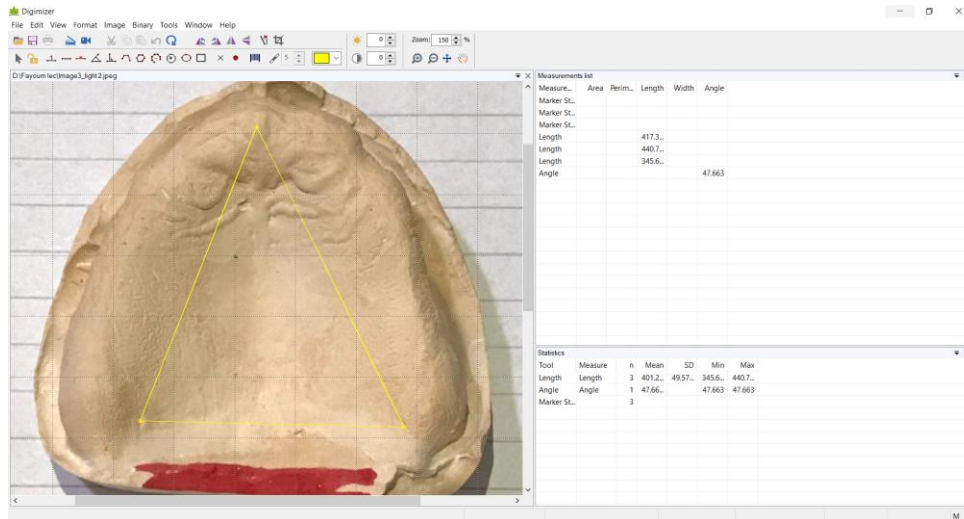


Figure (10):- Digimizer lines assessment of Medium with Putty Photo-Analysis.

The anterior angle initiated between lines and the length of these lines were gauged by utilizing the Digimizer® Software V. 4.3.1. initiating from the anterior line angle to each hamular notch where an additional third line links them. The three lines' mean were calibrated in length to simplify the comparative study.

Results:-

Statistical Analysis:

Statistical analysis was accomplished with SPSS 16 ® (Statistical Package for Scientific Studies), Graph pad Prism, and Windows Excel then displayed in 2 tables and 3 graphs. The granted data investigation was achieved by employing the Shapiro-Wilk and Kolmogorov-Smirnov tests for normality, which exposed original data from the ordinary data distribution. Consequently, the contrast between the four groups was stratified utilizing the One-Way ANOVA test tracked by Tukey's Post One. The Independent T-test aided in comparing the two dissimilar border molding and two diverse impression materials. The significance level was set at $P \leq 0.05$.

Comparison Between All Groups:

A comparison of parameter and angle measurements across the four dissimilar groups is displayed in Table 1 with Figures 11 and 12. The groups were differentiated by the nature of the material employed (Zn/O Eugenol or Medium) and the border molding material (Greenstick compound or Putty).

For The Parameter Measurements:

Zn/O Eugenol with Greenstick compound borders had the highest mean (1598.4) then Medium with Greenstick compound borders was the second (1575.1). While, Zn/O Eugenol with Putty borders was the third (1425.23), Medium with Putty borders had the lowest mean (1417.8) with an insignificant difference among all groups as $P=0.06$.

For The Angle Measurements:

Zn/O Eugenol with Greenstick compound borders had the highest mean (54.47°) then Medium with Greenstick compound borders was the second (50.29°). While, Medium with Putty borders was the third (47.56°), and Zn/O Eugenol with Putty borders had the lowest mean (47.38°) with an insignificant difference through all groups as $P=0.053$.

Table 1:- Descriptive Comparison between Results of Parameter and Angle Measurements in All Groups:

	Groups	Mean	Standard Deviation	P-value
Parameters	Zn /O Eugenol with Greenstick compound borders	1598.4	195.5	0.06
	Zn/O Eugenol with Putty borders	1425.23	182.5	
	Medium with Greenstick compound borders	1575.1	178.8	
	Medium with Putty borders	1417.8	191.5	

Angle	Zn /O Eugenol with Greenstick compound borders	54.47	6.78	0.053
	Zn/O Eugenol with Putty borders	47.38	5.98	
	Medium with Greenstick compound borders	50.29	6.15	
	Medium with Putty borders	47.56	5.89	

*Significant difference as $P < 0.05$.

Means with different superscript letters were significantly different as $P < 0.05$.

Means with the same superscript letters were insignificantly different as $P > 0.05$.

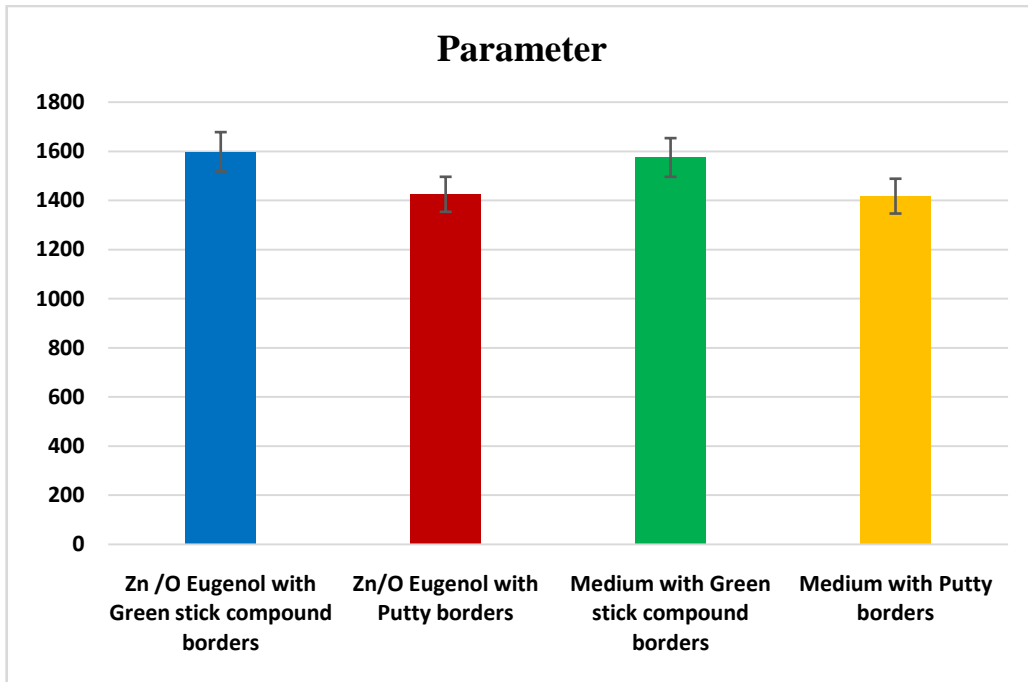


Figure (11):- Bar chart representing parameters in all groups.

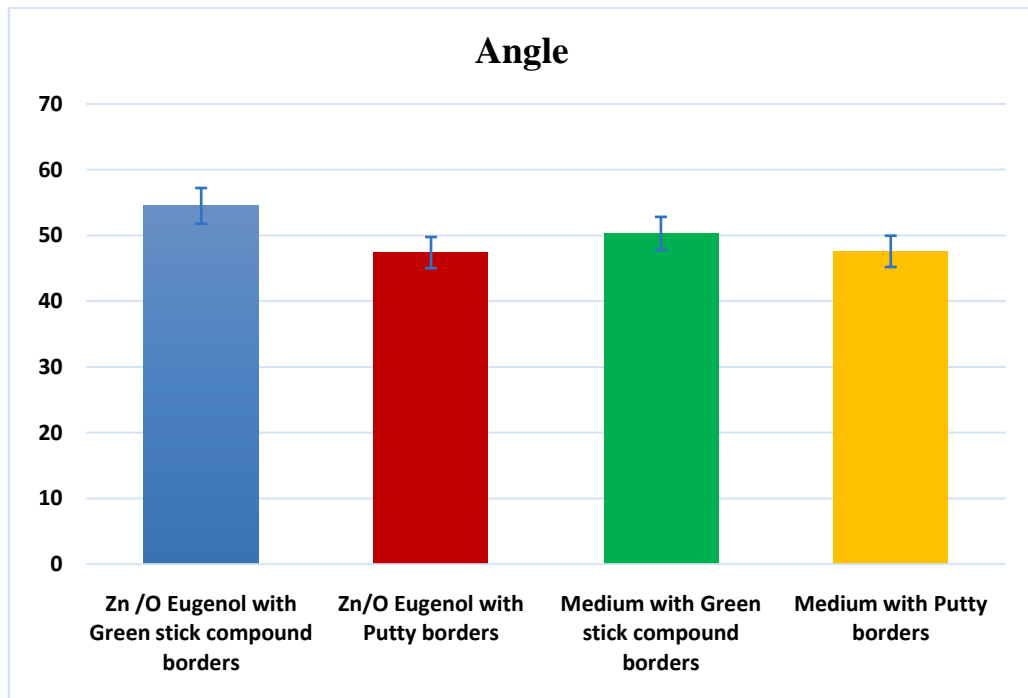


Figure (12):- Bar chart representing angles in all groups.

Comparison Between the Dissimilar Border Molding Materials' Effects Regardless of The Impression Material:

Comparison among the parameter and angle measurements for the two unlike border molding materials utilized; Greenstick compound and Putty were represented in Table 2 and Figure 13. Their outcomes display significant differences between the materials for both parameters and angles ($P > 0.05$ for both).

Table 2:- Descriptive Results of Parameter and Angle Regarding Different Border Molding Materials:

Border Molding Material		Mean	Standard Deviation	P-value
Parameters	Greenstick compound borders	1586.75	187.15	0.06
	Putty borders	1421.515	187	
Angle	Greenstick compound borders	52.38	6.465	0.09
	Putty borders	47.47	5.935	

*Significant difference as $P < 0.05$.

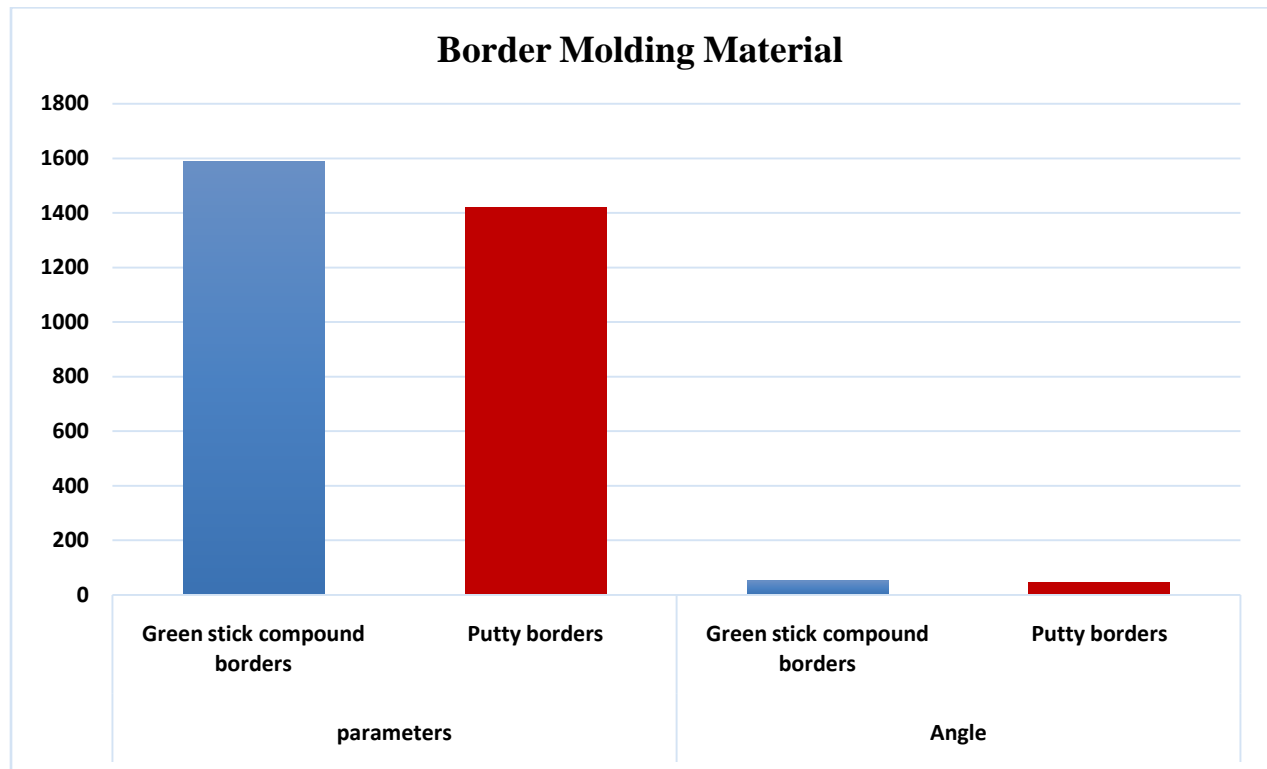


Figure (13):- Bar chart representing angle and parameter regarding diverse border molding materials.

Comparison Between the Different Impression Materials' Effects Regardless of The Border Molding Material:

Comparison among the parameter and angle measurements of the two dissimilar impression materials employed; Zn/O Eugenol and Medium were displayed in Table 3 and Figure 14. Their results reveal insignificant differences between the materials for both parameters and angles ($P > 0.05$ for both).

Table 3:- Descriptive Results of Parameter and Angle Regarding Different Impression Materials:

Impression Material		Mean	Standard Deviation	P-value
Parameters	Zn /O Eugenol	1511.82	189.00	0.85
	Medium	1496.45	185.15	
Angle	Zn /O Eugenol	50.93	6.38	0.48
	Medium	48.93	6.02	

*Significant difference as $P < 0.05$.

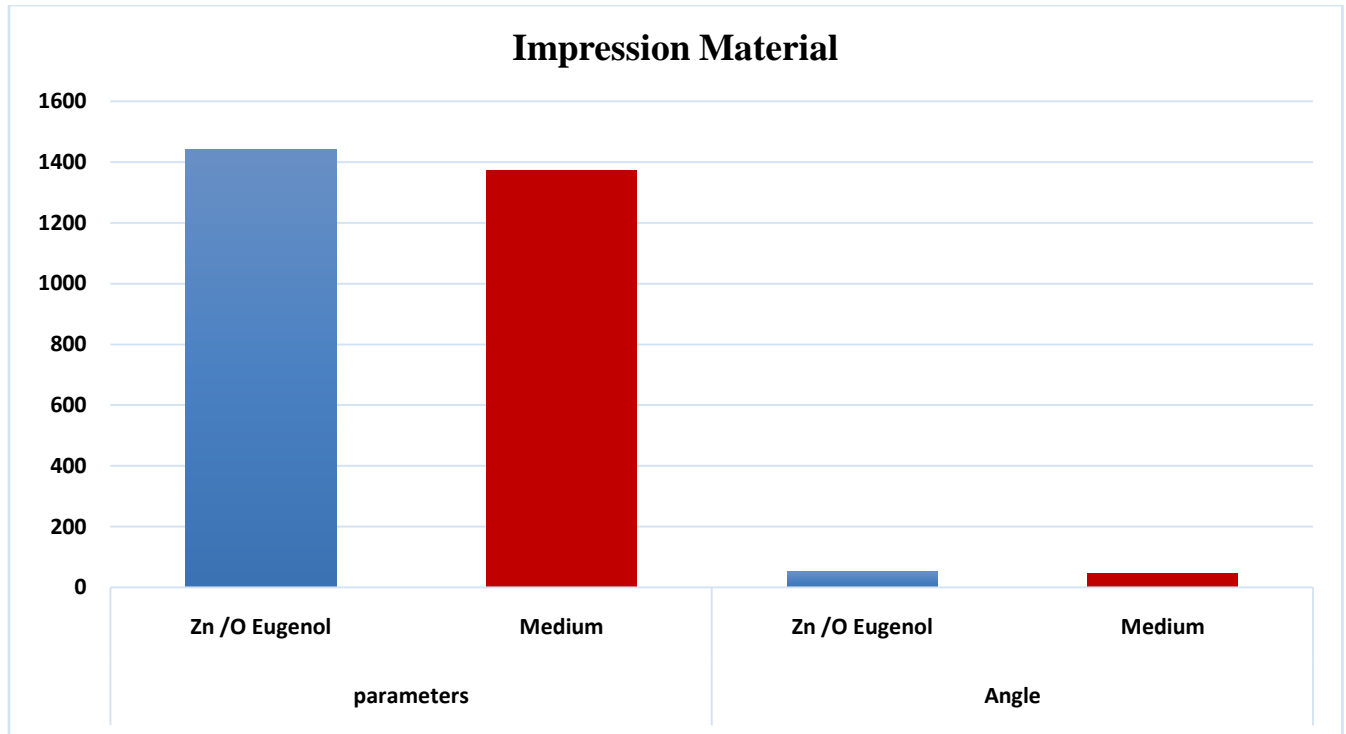


Figure (14):- Bar chart representing angle and parameter regarding unlike impression materials.

Discussion:-

This clinical study was conducted to photo-analytically evaluate and compare the dimensional accuracy of four different final maxillary completely edentulous impressions fabricated from two dissimilar border molding and wash impression materials. This was credited to the chief role these two procedures play in promoting adequate maxillary denture border seal during function and rest besides additive means of retention, support, and stability to withstand the gravitational attractive forces and sequentially providing a successful comfortable maxillary complete denture⁽¹¹⁾.

The aging inhabitants in developed nations have amplified the edentulous patients' quantity, and their prosthetic rehabilitation essentiality to progress their quality of life, hence, the complete denture is the chief handling option in these cases⁽¹²⁾. Although the tremendous materials and techniques that prosthodontists utilize for both border molding and final impression phases through complete denture fabrication, the materials employed for accomplishing these two procedures in the current contemplate were nominated for evaluation owing to their availability and popularity in all the oral prosthodontics departments of various Egyptian dental colleges.

All the attained dissimilar final maxillary impressions were constructed and divided into four groups rendering to their utilized border molding and impression materials' form to simplify their assessment. Additionally, bias was avoided in comparing the dimensional accuracy of all groups' impressions throughout the research succeeding a former study by inspecting all of them on the dental stone type IV casts with dimensionally equivalent standardized bases and supplying them all a comparable expansion rate⁽¹³⁾.

Furthermore, type IV dental stone was employed for its toughest and strongest nature in preserving the obtained impressions by averting any scratches or minor fractures in the final casts throughout the study. Moreover, an identical room temperature and humidity environment was an obligatory guideline for impression pouring as highlighted by the manufacturer, to abolish any atmospheric impacts and variations on the fabricated master casts and guarantee a truthful assessment procedure for all the groups' casts^(14,15).

Comparison between the four dissimilar final impressions took place accurately within similar values and circumstances by standardizing and securing both the angulation and space between the digital camera and

altogether the groups' casts through the photo shooting session, hence, facilitating analyses of all groups' acquired images.

The Digimizer software was employed in this research to estimate the dimensional accuracy of the two unlike border molding and impression materials by analyzing all groups' acquired images based on a previous study which revealed the Digimizer software's superior merits. Estimating the spatial and physical contents of various photographs in diverse fields of science, granting effortless and accurate assortment, expression, imitation, and distribution of a valued data range which is easily handled whenever desired are its major advantages^(16,17).

The outcomes of this work demonstrated that no statistically significant difference existed between the four impression groups concerning the maxillary angles and perimeter measurements. By other means; in terms of dimensional accuracy, all groups displayed an insignificant difference between the elastomeric impression materials applied for border molding (Putty) and the terminal wash impression (Medium) with the conventional ones used as the most widespread border molding material (Greenstick compound) and the gold standard material in constructing completely edentulous impressions (Zn/O Eugenol) as other studies described^(12,18).

The present research's consequences disclosed an insignificant difference between the two border molding materials employed in terms of dimensional accuracy regardless of the conventional material remarkably took a prolonged duration related to the rubber base one. This was in harmony with other studies' findings which stated that molding the borders via utilizing Greenstick compound and Putty rubber base materials accompanied by dissimilar terminal wash impression materials exhibited identical clinical retention based on their accuracy ending up an exceeded patient's comfort and satisfaction^(11,19).

The current findings declared that utilizing elastomeric impression materials in border molding and final impression steps not only provides equivalent accuracy, but is also more feasible, effortless, and cleaner than the conventional ones. This was in adherence with further research which stated that elastomers are quite convenient for border molding and ultimate wash impression procedures in complete denture fabrication owing to their reasonable dimensional stability and accuracy together with simply handling features and superior physical criteria sequentially ending up with patient's minimal expense of time, effort and awkwardness exclusively with inexperienced operators^(9,20).

The insignificant difference in the dimensional accuracy among the dissimilar impression groups might be attributed to the variability in the wash impression materials, structure, branding, polymerization shrinkage, and degree of recovery^(21,22). This study's results are in agreement with other ones which utilized the Digimizer software and concluded that, even though the versatility of impression materials in countless aspects and methods employed for attaining the terminal complete denture's impression, there is no evidence in concluding that maxillary complete dentures fabricated from versatile materials and techniques would significantly differ in their long-term clinical outcome^(10,23). The existing research's findings support its formerly postulated hypothesis.

Conclusions:-

Based on the presented findings it has been determined that; even though the recent elastomeric Putty and Medium rubber base impression materials are more feasible, cleaner to utilize, and proved to almost possess equivalent means of dimensional accuracy in comparison with the conventional materials, but still the most popular border molding material Greenstick compound and Zn/O eugenol impression paste which has always been considered as the gold standard secondary impression material have insignificantly more dimensional accuracy in fabricating final impressions for completely edentulous patients.

List of Abbreviations:

Zn/O eugenol: Zinc Oxide and Eugenol.

Funding:

This research is self-funded.

Declaration of Conflict:

All authors have declared no conflict of interest.

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