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A Comparative Study to Evaluate The Accuracy of Open Tray Splinted and Non-Splinted Implant Level Impressions and Impressions Obtained From Two Intraoral Scanners For Three Implants Placed in A Partially Edentulous Arch - An in Vitro Study

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Abstract

Title: A comparative study to evaluate the accuracy of open tray splinted and non-splinted implant level impressions and impressions obtained from two intraoral scanners for three implants placed in a partially edentulous arch - an in vitro study

Objective: The aim of this in vitro study was to compare and evaluate the accuracy of open tray splinted and non-splinted Implant level impression and impressions

obtained from two intraoral scanners for three implants placed in a partially edentulous arch and to evaluate which of the two scanners used (Trios 3 shape and Upsera intraoral scanners) has the better trueness and precision value.

Methods: Three implants were placed in a partially edentulous arch model simulating clinical conditions. Impressions were made using open tray splinted and non-splinted techniques and models were fabricated as well as the study model was scanned with two intraoral scanners (Trios 3 shape and Upsera intraoral scanners). The models were then digitally scanned and compared with a reference scan using a Exocad software. Measurements were made by superimposing the group scans over the reference scan.

Results: The results revealed that the open tray splinted impression technique was found more accurate than the non-splinted impression techniques. However, impressions obtained from trios 3 shape intraoral scanners showed significantly higher accuracy compared to the other scanner and the conventional impression techniques. The differences in accuracy were statistically significant ($p < 0.05$) at specific landmarks.

Conclusion: Within the limitations of this study, it can be concluded that open tray splinted was superior than non-splinted impression techniques in terms of accuracy for three implants placed in a partially edentulous arch. However, trios 3 shape intraoral scanners demonstrated superior accuracy compared to Upsera intraoral scanner and conventional impression techniques.

Keywords: Implant dentistry, implant impressions, intraoral scanners, open tray splinted impressions, non-splinted impressions, accuracy assessment, partially edentulous arch, digital dentistry.

Introduction

Intraoral scanners first appeared in 1980 and in 1987, a Swiss dentist and an Italian electrical engineer developed and introduced CEREC by Sirona Dental Systems. Digital impression devices are used alternatively to conventional impression techniques (1) with the advantage of providing comfort to the patient, time efficiency, and also the reduced costs. (2) Over the past few years, several commercial Intraoral scanning systems have been introduced to the market (3) like the TRIOS 3 color Pod, now in its fourth generation, was launched by 3 Shape in 2016, the Emerald (Planmeca) in 2017, the i500 (Medit) in 2018 (4) and Upsera intraoral scanner. This led to an increase in the number of intraoral scanners available in the market causing many clinicians to have a second thought about choosing the most suitable intraoral system. (2) It can be used in fixed partial dentures, complete dentures, and maxillofacial prosthesis. It has also been very useful in treatment planning till the definitive prosthetic work in implant dentistry. As this field is still evolving with high future growth potential, (5) accuracy is mandatory to achieve optimal clinical results. (6) Accuracy is defined as the "closeness of agreement between a measured quantity value and a true quantity value of a measurand". It is expressed by trueness and precision. (5) According to the ISO international standard number 5725, trueness is the ability of a measurement or measuring device to match the actual value of the quantity being measured, whereas precision is the ability of a measurement or measuring device to consistently repeat a particular measurement. (4) Hence, the aim of this study is to evaluate and compare the accuracy of impression obtained from two intraoral scanners and two conventional implant level impressions and to know which is the more accurate technique for implant impression making.

Aim of the study

Aim of the present study was to evaluate the accuracy of open tray splinted and non-splinted Implant level impressions and impressions obtained from two intraoral scanners for three implants placed in a partially edentulous arch.

Objectives of the study

Primary Objective

To compare and evaluate the accuracy of open tray splinted and non-splinted Implant level impression and impressions obtained from two intraoral scanners for three implants placed in a partially edentulous arch.

Secondary Objectives

- To evaluate which of the two scanners has the better trueness value.
- To evaluate which of the two scanners has the better precision value.

Material and Methods

The study was done in the laboratory of Department of Prosthodontics, Crown and Bridge. The total number of 56 models were included in study. They were then grouped into 4 categories containing 14 casts in each group. Every cast contained 3 implants.

Consent waiver was obtained from the Institutional Ethical Committee for this study.

Study method

Control model

An impression of a mandibular ideal cast was made using putty. Modelling wax was melted and poured in the impression mould and was freezed (fig. 1). The wax model was removed and invested into a flask and was processed with a heat cure clear acrylic resin material to fabricate a mandibular partially edentulous model with missing 1st premolar, 2nd premolar, 1st molar and 2nd molar.(fig. 2) The model was finished and polished.

Figure 1: wax pattern for master model

Figure 2: master model fabricated from heat cure clear acrylic resin

Three dental implants of size 4.5 x 10mm was placed parallel to each other in 1st premolar, 1st molar and 2nd molar region with the help of a dental surveyor (fig. 3). These implants were cemented in the model using resin cement. This master model was scanned using a laboratory scanner (fig. 5) after screwing the scan bodies (fig. 4) and the .STL file were generated.

Control group- The .STL file developed by scanning the master model using a laboratory scanner (fig. 6)

Figure 3: implants placed with the help of surveyor

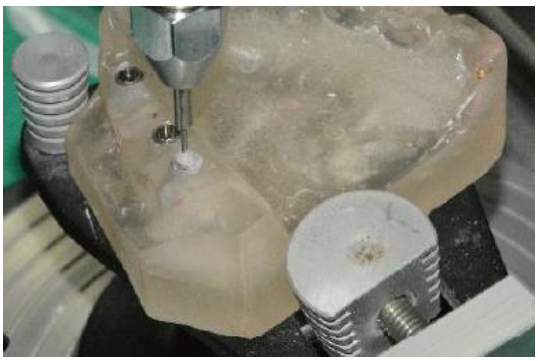


Figure 4: scan bodies attached to the implants

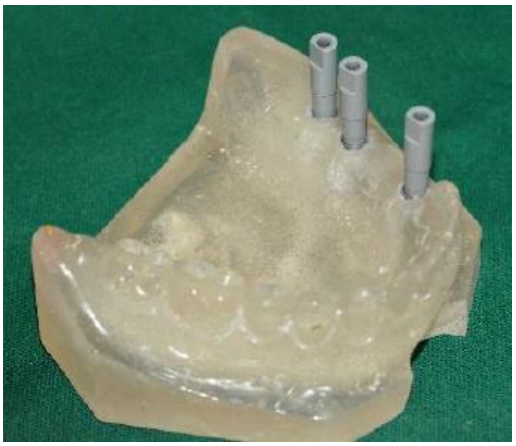


Figure 5: master model scanned using laboratory scanner

Figure 6: STL file generated from laboratory scanner (control group scan)

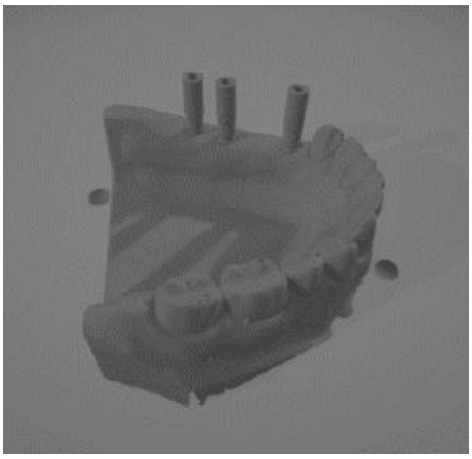


Figure 7: splinting the impression copings for group 1

Figure 8: 14 models were with type 4 dental stones from splinted impressions

Figure 9: 14 models were with type 4 dental stones from non-splinted impressions

Group 1- Open tray splinted impression.

Three open tray implant impression copings were screwed into the dental implant, where they were splinted with floss and then pattern resin added over it. After polymerization, the resin structure was cut using a diamond disk (Fig. 7). Twenty-four hours later, the structure was resplinted to reduce the shrinkage of the resin. A plastic tray was perforated corresponding to the positions of the transfer copings to allow the placement and removal of the screws. An impression was made with polyvinyl siloxane impression material, following the manufacturer's instructions. Once the impression

material has set, the impression was removed by unscrewing the transfer copings. Implant analogs were then screwed into the transfer copings which were picked up along with the impression. Lab analogues were attached to the impression copings. Gingival mask was applied along the lab analogues. The impression was then poured using die stone. A total of 14 models were fabricated (fig. 8). These models were scanned using laboratory scanner and a .STL file were developed (fig. 10).

(Fig. 6): .STL file generated from laboratory scanner (control group scan)

(Fig. 7): splinting the impression copings for group 1

(fig. 8) 14 models were with type 4 dental stones from splinted impressions

(fig. 9) 14 models were with type 4 dental stones from non-splinted impressions

Group 2—Open tray non-splinted impression.

Three open tray transfer impression copings were screwed into the dental implants. Three perforations were made in a plastic tray according to the positions of the transfer copings to allow the placement and removal of the screws. An impression was made with polyvinyl siloxane impression material following the manufacturer's instructions. Once the impression material had set, the impression was removed by unscrewing the transfer copings. Lab analogues were attached to the impression copings. Gingival mask was applied along the lab analogues. The impression was then poured using die stone. A total of 14 models were fabricated (fig. 9). This model was scanned using laboratory scanner and a .STL file was developed (fig. 11).

Figure 10: .STL file generated from splinted models

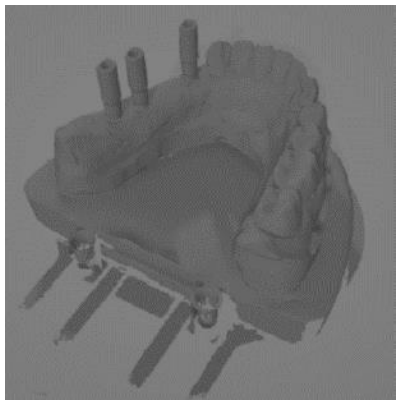


Figure 11: STL file generated from non-splinted models

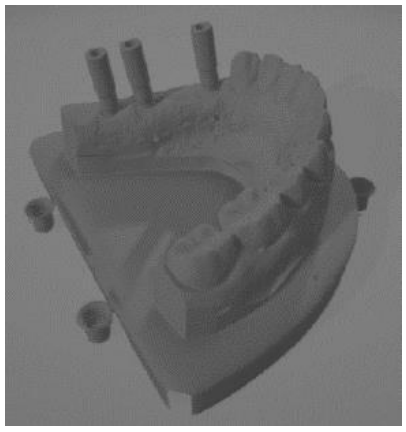


Figure 12: STL file generated from trios 3 shape intraoral

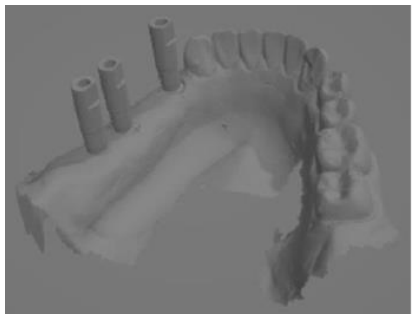


Figure 13: STL file generated from Upsera intraoral scanner

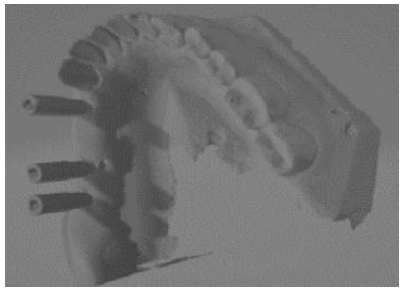
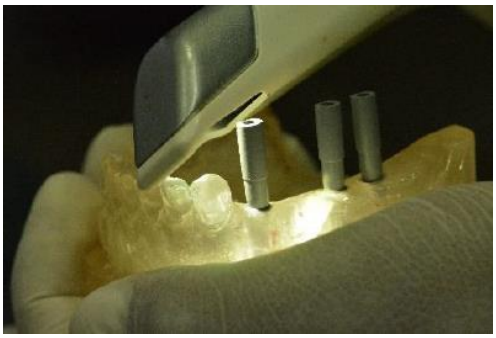


Figure 14: scanning the master model with the intraoral scanner



Group 3

Scan body were placed on the master model and the model were scanned using Upsera intraoral scanner. A .STL file were produced. A total of 14 samples were fabricated. (fig 13)

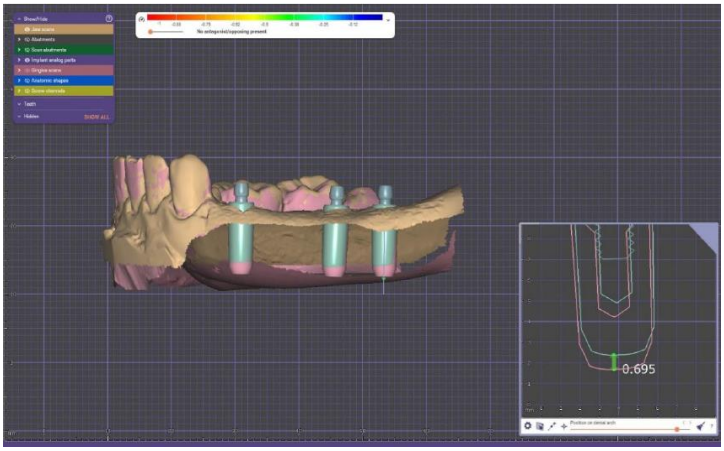
Group 4

Scan body were placed on the master model and the model were scanned using Trios 3 shape intraoral scanner. A .STL file were produced. A total of 14 samples were fabricated. (fig 12)

Figure 15: Upsera intraoral scanner

Figure 16: Upsera intraoral scanner

Figure 17: measuring the trueness and precision values by superimposition of the group scans over the reference scan.



Trueness values were obtained by superimposing the .STL files from the test groups (group 1,2,3,4) with the .STL file from the master model control group scan (fig. 17).

Precision value was generated by overlapping the .STL files within each group. Exocad dental CAD software were used for this procedure.

Overall trueness and precision of the scanners were analysed and compared and the statistical analysis was done.

Results

The aim of the present study was to evaluate the accuracy of open tray splinted and non-splinted Implant level impressions and impressions obtained from two intraoral scanners for three implants placed in a partially edentulous arch.

The study was done in the laboratory of Department of Prosthodontics, Crown and Bridge. The total number of 56 models were grouped into 4 categories containing 14 casts in each group. Every cast were fabricated with 3 implants. The observations were recorded in an Excel sheet.

After that statistical analysis was done for all study variables.

Table 1: Comparison of accuracy for Implant 1 among four groups

Groups	No of sample	Mean	SD	F value	p-value
Non-splinted	14	0.52	0.17	16.261	<0.001*
Splinted	14	0.37	0.17		
Shape scanner	14	0.22	0.07		
Upsera	14	0.23	0.06		

One-way ANOVA test; * indicates a significant difference at p≤0.05

Table 1 shows comparison of accuracy for Implant 1 among the four groups. Least discrepancy was seen in the Shape scanner groups with a mean of 0.22±0.17 followed by the Upsera group with a mean of 0.23±0.06 and Splinted group with a mean of 0.37±0.17. Highest discrepancy was seen in the non-splinted group with a mean of 0.52±0.17. This difference in the accuracy for Implant 1 among the four groups was statistically significant.

Graph 1: Comparison of accuracy for Implant 1 among four groups

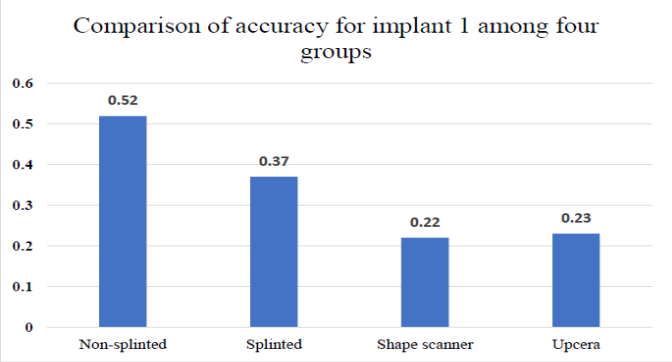


Table 2: Pairwise comparison of accuracy for implant 1 among four groups

Groups	p-value
Non-splinted vs Splinted	0.026*
Non-splinted vs Shape scanner	<0.001*
Non-splinted vs Upsera	<0.001*
Splinted vs Shape scanner	0.016*
Splinted vs Upsera	0.024*
Shape scanner vs Upsera	0.999

Poct hoc Tukey test; * indicates a significant difference at p≤0.05

Table 2 shows the results of the pairwise comparison of accuracy for implant 1 among four groups. Non-splinted group showed a significantly greater discrepancy as compared to the other three groups. Also, discrepancy in the Splinted group was significantly greater than that of the shape scanner and Upsera groups. There was no difference in the discrepancy of Shape scanner and Upsera groups in Implant 1.

Table 3: Comparison of accuracy for Implant 2 among four groups

Groups	No of sample	Mean	SD	F value	p-value
Non-splinted	14	0.61	0.17	37.120	<0.001*
Splinted	14	0.35	0.12		
Shape scanner	14	0.23	0.04		
Upsera	14	0.23	0.05		

One-way ANOVA test; * indicates a significant difference at p≤0.05

Table 3 shows comparison of accuracy for Implant 2 among the four groups. Least discrepancy was seen in the Shape scanner with a mean of 0.23±0.04 followed by Upsera group with a mean of 0.23±0.05 and Splinted group with a mean of 0.35±0.12. Highest discrepancy was seen in the non-splinted group with a mean of 0.61±0.17. This difference in the accuracy for Implant 2 among the four groups was statistically significant.

Graph 2: Comparison of accuracy for Implant 2 among four groups

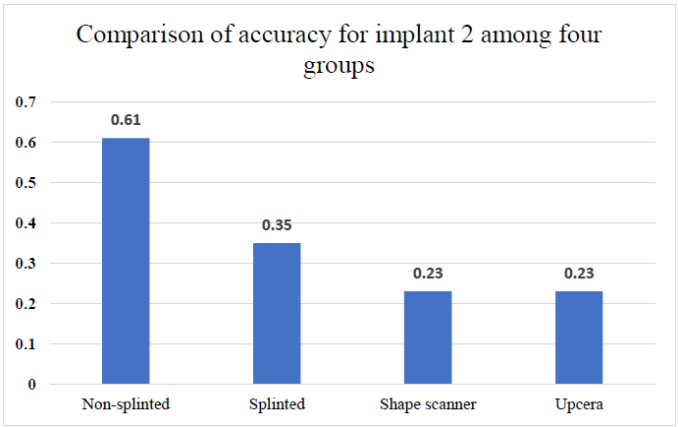


Table 4: Pairwise comparison of accuracy for implant 2 among four groups

Groups	p-value
Non-splinted vs Splinted	<0.001*
Non-splinted vs Shape scanner	<0.001*
Non-splinted vs Upsera	<0.001*
Splinted vs Shape scanner	0.024*
Splinted vs Upsera	0.018*
Shape scanner vs Upsera	1.000

Poct hoc Tukey test; * indicates a significant difference at p≤0.05

Table 4 shows the results of the pairwise comparison of accuracy for implant 2 among four groups. Non-splinted group showed a significantly greater discrepancy as compared to the other three groups. Also, discrepancy seen in the Splinted group was significantly greater than that of the Shape scanner and Upsera groups. There was no difference in the discrepancy of Shape scanner and Upsera groups in Implant 2.

Table 5: Comparison of accuracy for Implant 3 among four groups

Groups	No of sample	Mean	SD	F value	p-value
Non-splinted	14	0.45	0.21	13.475	<0.001*
Splinted	14	0.42	0.09		
Shape scanner	14	0.24	0.04		
Upsera	14	0.23	0.05		

One-way ANOVA test; * indicates a significant difference at p≤0.05

Table 5 shows compares the accuracy for Implant 3 among the four groups. Least discrepancy was seen in the Shape scanner groups with a mean of 0.24± 0.04 followed by the Upsera group with a mean of 0.23± 0.05 and Splinted group with a mean of 0.42± 0.09. Highest discrepancy was seen in the non-splinted group with a mean of 0.45±0.21. This difference in the accuracy for Implant 3 among the four groups was statistically significant.

Graph 3**:** Comparison of accuracy for Implant 3 among four groups

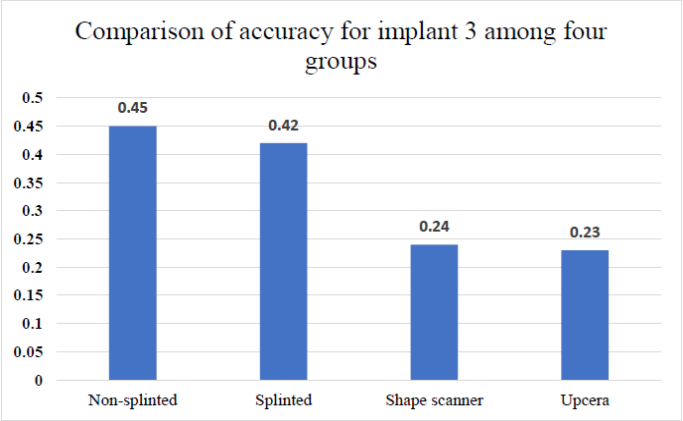


Table 6: Pairwise comparison of accuracy for implant 3 among four groups

Groups	p-value
Non-splinted vs Splinted	0.943
Non-splinted vs Shape scanner	<0.001*
Non-splinted vs Upsera	<0.001*
Splinted vs Shape scanner	0.001*
Splinted vs Upsera	<0.001*
Shape scanner vs Upsera	0.975

Poct hoc Tukey test; * indicates a significant difference at p≤0.05

Table 6 shows the results of the pairwise comparison of accuracy for Implant 3 among four groups. Non-splinted group showed a significantly greater discrepancy as compared to the shape scanner and Upsera group. Also, discrepancy in the Splinted group was significantly greater than that of the Shape scanner and Upsera group. Discrepancy among Non-splinted and Splinted groups was almost similar for Implant 3. Also, there was no difference in the discrepancy of Shape scanner and Upsera groups in Implant 3.

Table 7: Comparison of accuracy of three implants within Non-splinted group

Implant	No of sample	Mean	SD	F value	p-value
Implant 1	14	0.52	0.17	2.923	0.066
Implant 2	14	0.61	0.17		
Implant 3	14	0.45	0.21		

One-way ANOVA test

Table 7 shows comparison of accuracy of three implants within Non-splinted group. The least discrepancy in the Non-splinted group was seen in Implant 3 with a mean of 0.45±0.21 followed by Implant 1 with mean of 0.52± 0.17. The highest discrepancy was seen in Implant 2 with a mean of 0.61±0.17. However, there was a non-significant difference in the accuracy of three implant within Non-splinted group.

Graph 4: Comparison of accuracy of three implants within Non-splinted group

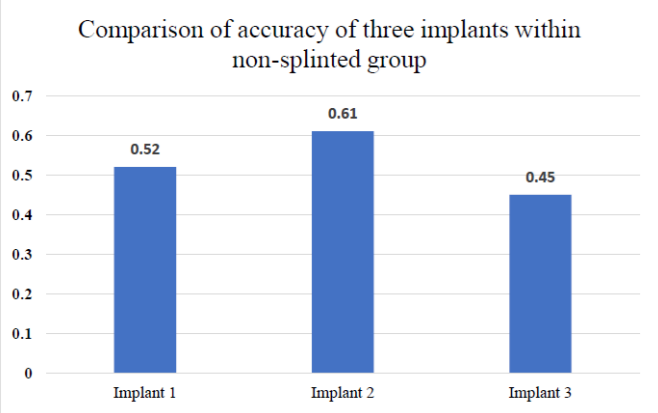


Table 8: Comparison of accuracy of three implants within Splinted group

Implant	No of sample	Mean	SD	F value	p-value
Implant 1	14	0.37	0.17	0.922	0.406
Implant 2	14	0.35	0.12		
Implant 3	14	0.42	0.09		

One-way ANOVA test

Table 8 shows comparison of accuracy of three implants within Splinted group. The least discrepancy in the splinted group was seen in Implant 2 with a mean of 0.35± 0.12 followed by Implant 1 with a mean of 0.37± 0.17. The highest discrepancy was seen in the Implant 3 with a mean of 0.42±0.09. However, there was a non-significant difference in the accuracy of three implant within Splinted group.

Graph 5: Comparison of accuracy of three implants within Splinted group

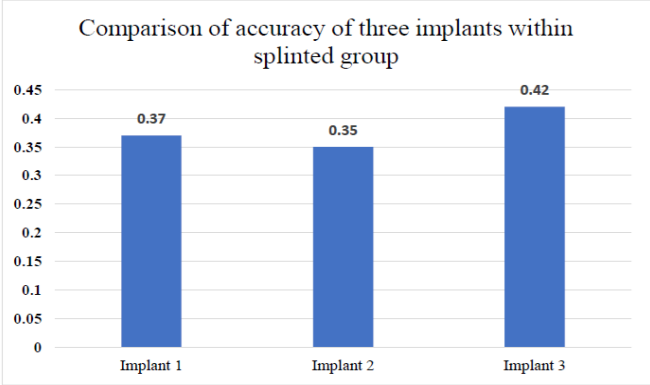


Table 9: Comparison of accuracy of three implants within Shape scanner

Implant	No of sample	Mean	SD	F value	p-value
Implant 1	14	0.22	0.07	0.493	0.614
Implant 2	14	0.23	0.04		
Implant 3	14	0.24	0.04		

One-way ANOVA test

Table 9 shows comparison of accuracy of three implants within Shape scanner group. The least discrepancy in the Shape scanner group was seen in Implant 1 with a mean of 0.22± 0.07 followed by 0.23±0.04. The highest discrepancy in the Shape scanner group was seen in the Implant 3 with a mean of 0.24±0.04. However, there was a non-significant difference in the accuracy of three implant within Shape scanner group.

Graph 6: Comparison of accuracy of three implants within Shape scanner

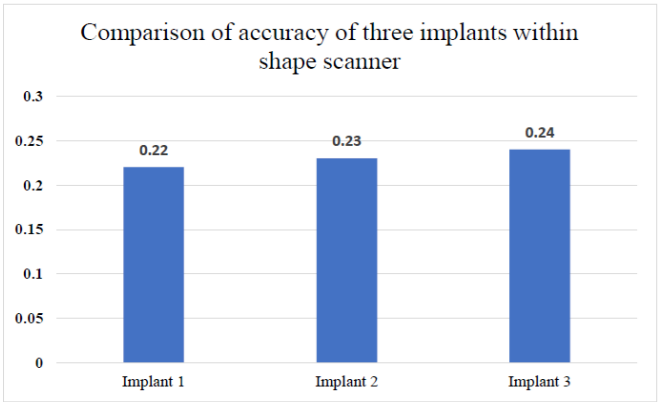


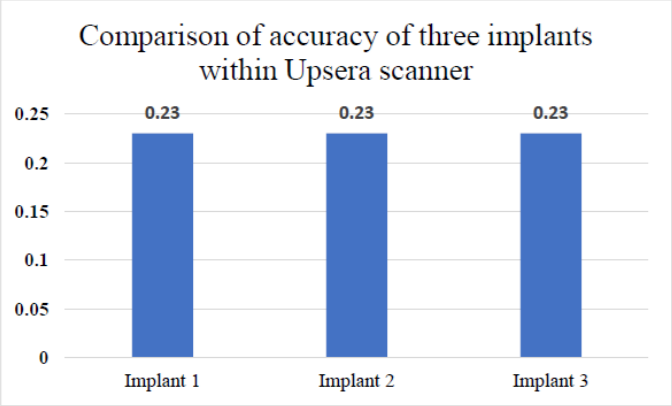
Table 10: Comparison of accuracy of three implants within Upsera scanner

Implant	No of sample	Mean	SD	F value	p-value
Implant 1	14	0.23	0.06	0.061	0.941
Implant 2	14	0.23	0.05		
Implant 3	14	0.23	0.05		

One-way ANOVA test

Table 10 shows comparison of accuracy of three implants within Upsera group. The discrepancy across three implants was similar with a mean of 0.23±0.06 in Implant 1, 0.23±0.05 in Implant 2 and Implant 3

Graph 7: Comparison of accuracy of three implants within Upsera scanner



Discussion

Accurately recording implant locations is an integral prerequisite for fabricating a precisely fitting prosthesis, either by digital or conventional impression techniques. In the workflow of conventional procedures, the splinted open-tray impression technique is mostly used to transfer the implant positions from the patient's mouth through the impression material. The splinted open-tray impression technique provides acceptable clinical results, but it requires complicated procedures that are time consuming and discomforting to the patient. With the development of CAD/CAM, digital impression methods have gained popularity in implant dentistry. Intraoral scanning is a widely used digital impression technique in clinical practice.

Conventional and digital impression techniques each have their own advantages and disadvantages for the fabrication of prosthetic restorations. The present study was performed to evaluate the accuracy of open tray splinted and non-splinted Implant level impressions and impressions obtained from two intraoral scanners for three implants placed in a partially edentulous arch.

3 implants were placed on mandibular cast with a position on 1st premolar, 1st molar and 2nd molar. When all the implants were compared between conventional open tray- splinted and non-splinted and intraoral scanners - Trio 3 shape scanner and Upsera intraoral scanning techniques, the implant 1 group showed Trios 3 shape scanner resulted with least discrepancy with a mean of 0.22±0.17 followed by the Upsera intraoral scanner group with a mean of 0.23±0.06. Then splinted group with a mean of 0.37±0.17 and highest discrepancy was seen in the non-splinted group with a mean of 0.52±0.17. The non-splinted group showed a significantly greatest discrepancy as compared to the other three groups in implant 1 with no significant difference between Trio 3 shape scanner and Upsera intraoral scanner groups.

Similar result was seen in implant 2 with a result of least discrepancy in the Trio 3 shape scanner with a mean of 0.23±0.04 followed by Upsera intraoral scanner group with a mean of 0.23±0.05. Then Splinted group with a mean of 0.35±0.12 and highest discrepancy seen in the non-splinted group with a mean of 0.61±0.17. The Non-splinted group showed a significantly greater discrepancy as compared to the other three groups and no significant difference in the discrepancy of Trio 3 shape scanner and Upsera intraoral scanner groups in Implant 2.

Likewise implant 3 has shown the same result i.e least discrepancy in the Trio 3 shape intraoral scanner groups with a mean of 0.24± 0.04 followed by the Upsera intraoral scanner group with a mean of 0.23± 0.05 and Splinted group with a mean of 0.42± 0.09. The highest discrepancy was seen in the non-splinted group with a mean of 0.45±0.21. Thus Non-splinted group showed a significantly greater discrepancy as compared to the Trio 3 shape scanner and Upsera group. Also, discrepancy in the Splinted group was significantly greater than that of the Trio 3 shape scanner and Upsera intraoral scanner group. The discrepancy among Non-splinted and Splinted groups was almost similar for Implant 3. Also, there was no significant difference seen in the discrepancy of Trio 3 shape scanner and Upsera groups in Implant 3.

When all the 3 implants were compared within non-splinted group, least discrepancy was seen in Implant 3 with a mean of 0.45±0.21 followed by Implant 1 with mean of 0.52± 0.17. The highest discrepancy was seen in Implant 2 with a mean of 0.61±0.17. However, there was a no significant difference in the accuracy of three implant within Non-splinted group. When implants were compared within splinted group, least discrepancy was seen in Implant 2 with a mean of 0.35± 0.12 followed by Implant 1 with a mean of 0.37± 0.17. The highest discrepancy was seen in the Implant 3 with a mean of 0.42±0.09. It resulted that there was a no significant difference in the accuracy of three implant within Splinted group similar to non-splinted group.

Then all the 3 implants were compared within intraoral scanner groups firstly with Trio 3 shape scanner group which showed that least discrepancy in Implant 1 with a mean of 0.22± 0.07 followed by 0.23±0.04. The highest discrepancy in the Trio 3 shape scanner group was seen in the Implant 3 with a mean of 0.24±0.04. However, there was a no significant difference in the accuracy of three implant within Trio 3 shape scanner group. Then 3 implants were compared within Upsera intraoral scanner group but founded that the discrepancy across three implants was similar with a mean of 0.23±0.06 in Implant 1, 0.23±0.05 in Implant 2 and Implant 3. Thus both intraoral scanner showed similar result with no significant differences within all the implants and also similar to conventional techniques groups. The present study manifested with all the above results that within all the techniques used either conventional or intraoral scanner, the implant's position cannot make huge difference for the reading obtained from them. "Trueness" was used to describe the deviation between test files and reference file. Trueness value was assessed on overall result on accuracy of intraoral scanner with that being the Trios 3 shape scanner with most accuracy compared to Upsera intraoral scanner and both conventional techniques. "Precision" was used to describe the closeness between test files. Precision was assessed through superimposition of 3D models generated from repeated Trios 3 shape scanner and Upsera intraoral scanner. The present study demonstrated that precision value of Trio 3 shape scanner was more of a close to reference value after superimpositions on the three reference areas for precision testing.

we found that intraoral scanners give more accuracy with less discrepancy than conventional techniques. Between both the intraoral scanners the Trio 3 shape scanner show less discrepancy with more accuracy compared to Upsera scanner. Also the Trio 3 shape scanner showed no significant difference in mean value of accuracy obtained between 3 implants suggestive of no significant difference in position of implants.

Thus trios 3 shape scanner is more accurate compared to Upsera intraoral scanner and conventional techniques according to our study.

Limitations

1. The study was performed in in-vitro condition, in absence of saliva, teeth, occluding jaw and other disturbances.
2. More knowledge with practice is required for performing the particular specialized intraoral scanners.
3. High cost in intraoral scanners techniques with specialized equipment.
4. The present study has included only mandibular cast for determination of trueness and precision of intraoral scanners.

Clinical Significance

1. Intraoral scanners are easy to use and requires less dental material.
2. Intraoral scanners are less time consuming than fabricating conventional techniques with less patient discomfort.
3. It reduces the chair time as well as visit, comforting patients as well as assistants, thus increasing the workflow.
4. Accuracy of the implant impressions using intraoral scanners is more compared to conventional techniques.
5. Intraoral scanner display a patient's 3D-impression of the intraoral structures on a screen so that errors, if any can be rectified by rescanning.
6. As intraoral scanners give images, it can give better appreciation to patient in understanding their own condition.
7. Digital techniques provide proper shade matching through its AI features.

Conclusion

Within the limitations of this in vitro study, the following conclusion can be drawn.

1. The intraoral scanners showed better accuracy than the conventional impression technique.
2. The splinted open tray impression technique was more accurate than non splinted open tray impression technique.
3. Among the two intra oral scanners used, trios 3 shape was better in terms of trueness and precision values as compared to Upsera intraoral scanners

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