Author’s response to reviews

Title: Accuracy of four intraoral scanners in oral implantology: a comparative in vitro study

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Author’s response to reviews:

Dear BMC Oral Health,

Dear Editor-in-Chief, Dr. Cecilia Devoto,

i am pleased to resubmit to your attention, after an (essential) revision, my research article titled: “Accuracy of four intraoral scanners in oral implantology: a comparative in vitro study”.

the text has been carefully modified according to your suggestions.

With the warmest regards,

Francesco Mangano, DDS, PhD, FICD

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Editor Comments:

1) On the title page, please include the email addresses of all co-authors.

I have added the emails of all authors, as requested.

2) In the abstract, please use the following headings:

- Background
- Methods
- Results
- Conclusions

I have modified the Abstract as requested, but in order to change the heading from “Purpose” to “Background” i had necessarily to introduce a short sentence to provide a background for this study:

“Until now, only a few studies have compared the ability of different intraoral scanners (IOS) to capture high-quality impressions in patients with dental implants. Hence, the aim of this study was to compare the trueness and precision of four IOS in a partially edentulous model (PEM) with three implants and in a fully edentulous model (FEM) with six implants”.

I think it was strictly needed- we could not start the “Background” section with a sentence like “To compare..”. A background was needed.

3) After the List of Abbreviations, please add the Heading "Declarations" with the following sub-headings:

Declarations

- Ethics approval and consent to participate
- Consent to publish
- Availability of data and materials
- Competing interests
- Funding
- Authors' Contributions

- Acknowledgements

- Authors' Information

We have modified the text, as requested. The authors’ information have been moved from the first page to this section, as requested.

4) Under the heading "Consent to Publish", please state "Not applicable" because the manuscript does not contain data from any individual person.

We have modified the text, as requested.

5) Under the heading "Competing Interests" please state that Dr Francesco Mangano is a Section Editor for BMC Oral Health.

We have modified the text, as requested.

BMC Oral Health operates a policy of open peer review, which means that you will be able to see the names of the reviewers who provided the reports via the online peer review system. We encourage you to also view the reports there, via the action links on the left-hand side of the page, to see the names of the reviewers.

Reviewer reports:

Reviewer 1:

This paper is really interesting because it deals with a very hot topic in oral implantology- the accuracy of different intraoral scanners and therefore the possibility of a full digital workflow in implantology.

To my knowledge, this is the second work of the authors on this topic and i believe it is more valuable than the first one (Mangano F. et al, Plos One 2016) for two reasons. First, the present paper compares the accuracy (sum of trueness + precision) of the most important IOS currently available in the market, with the latest software releases. Second, the present paper investigates the accuracy of the different IOS in two different situations - a partially and a totally edentulous model, respectively - and the models of the partially edentulous were in the present work adequately cut and trimmed, in order to perform a reliable evaluation (in the previous study published in the Plos One, the authors did not trimmed the partially edentulous model, and as a consequence, they found no statistically significant differences in the general trueness/precision of the different IOS- that could be considered a bias). For these reasons, i find this study extremely valuable.
I have no specific comments on the design of the study- it is perfectly designed.

The title is appropriate and the Abstract is clear and concise, as it contains all the relevant results of the study.

The Keywords are appropriate.

The introduction is easily readable even for the reader who has no experience in the use of IOS; however, all the most important information are included to provide a background for the study.

The M&M section fully describes the methods of this work- and basically the authors have repeated the design of their previous work and the works of Patzelt and coll., that are correctly cited in the reference list. I understand the use of a powerful industrial scanner as reference- hypothetically, an articulated arm or a cmm machine would be a better choice as reference, but it is clear that these devices can damage the models probing their surface- so i agree with the authors with the choice of a powerful active non-contact scanner for reference. In addition, this section is really informative because it describes all the main features of the different IOS, with order and again it is clear and concise. The superimposition method is described in sufficient details, and the references are pertinent.

It would be great in a future study, to include also the new scanner from Dentalwings - dwio - that is considered really powerful too, but i understand that the preparation of the present work was very long and difficult with so many scans and superimpositions.

The results section is clear, concise, with all relevant information included. Let me say that this information will have an impact in the world of dentistry- to date, there are no high quality comparative studies investigating the performance of different IOS at this level.

The Discussion is well written as it reports the results of the previous studies and then it compares these results with the present outcomes. The authors have underlined here the problem of scanning multiple implants for long-span restorations, and they draw very reasonable conclusions. In addition, the limitations of the present study are clearly stated. A larger sample size would be preferrable, and also it would be very interesting to perform a study on the local accuracy- calculating the linear and angular distances between the different scanbodies. This could be the topic of the next investigation.

The Conclusions are pertinent concise and related to this study.

The reference list is pertinent and it contains all the most important works in the present literature.

The tables are rich of information and easy to read, with a clear representation of the statistical evaluations.
Finally, the pictures are ok- and i have noted that different thresholds have been selected for the colorimetric maps of the partially and totally edentulous models, i agree with this.

The language is clear and it does not need editing or further revision.

Thank you very much.

Reviewer 2:

Good research article that focuses its attention on an interesting and highly debated topic in oral implantology and digital dentistry: are the intraoral scanners sufficiently accurate for use in oral implantology, in challenging situations? The title, abstract and the introduction are highly informative and pertinent. The methods are well described. The authors prepared two stone cast models, one of a partially edentulous patient with 3 implants and one of a totally edentulous patient with 6 implants. They tested the accuracy (trueness and precision) of the four most important (and expensive) devices that are currently available in the market and they did this in these two in vitro situations. To test trueness, they superimposed the stl files obtained with the different intraoral scanners with a reference stl file, obtained scanning the models with a powerful industrial desktop scanner. To investigate the precision, the authors superimposed the different scans obtained with the intraoral devices within each group (4 groups, 4 devices). I appreciate the design of the study, the rigorous scientific method, the wide knowledge of the literature. The methods were basically the same of the previous study of the authors and of previously published works on this topic (Prof. Strub and colleagues), so the methods have been already validated, and are reproducible by other research groups. I agree with the authors about the choice of stone cast models for the stability of the material in the long-term (as alternative, metal models should be employed as they could allow to use more accurate reference devices, like contact / probe scanners. in fact, probing the surface of the stone cast models may damage them. however, metal models are difficult to scan with the intraoral devices, because they have shiny surfaces that reflect light). I believe the two situations reproduced in the models of this study are really interesting and important for the clinicians.

The superimposition method is sound and valuable, and well related to the present literature on the topic. Most of all, the results are very important and of broad interest for all the readers, because it is difficult to find scientific evidence today in a world (digital dentistry) that is new and mainly driven by the Producers of the devices and the implant Companies. The results are well presented in a clear manner, and they are of great importance because of the devices studied here and because they clarified some issues about intraoral scanners in general; in addition, further evidence is added on the literature by this study. The Discussion is simple and clear, there is nothing more to add since there are not a lot of studies on this selected topic. Finally, the Conclusion chapter summarizes the most relevant findings emerging from this research. The References are complete and the list is not unnecessarily long. The Tables and Figures are further informative. The supplementary material is not informative, but considering the good quality of the study, this is a secondary aspect.
Thank you very much.