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THE ACCURACY OF ANGULATED IMPLANT IMPRESSIONS: A SYSTEMATIC REVIEW

Dental Science

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ABSTRACT

Implant with an axial orientation that is not in line with the needs of prosthetic rehabilitation may occur for various reasons. As a result, the impression procedure may be adversely influenced. Inaccuracies during impressions inevitably lead to laboratory errors resulting in lack of precision and misfit of the restoration. The accuracy of the implant cast depends on many factors; the type of impression material, implant impression technique, the implant angulation, the die material accuracy, and the master cast. All these techniques and factors were introduced and investigated for accuracy, but results were not always consistent. The purposes of the present review were to investigate 1) The scientific data related to different aspects of angulated implant impression accuracy and 2) To examine the clinical factors affecting the implant impression accuracy.

KEYWORDS

implant, angulated implants, implant impressions, impression materials, impression techniques

I. Introduction:

The first and the most crucial step in achieving an accurate, passively fitting prosthesis is making an accurate impression. The impression registers its three -dimensional position, which includes the depth, axis or angulations, and rotation or position relative to other implants, adjacent teeth, and dentition of the opposing arch. An accurate transfer of the hexagon position of the implant to the working cast is mandatory to achieve a functional and esthetic restoration.1 The accuracy of the implant cast depends on the type of impression material, the implant impression technique, the implant angulation, the connection type, and the accuracy of the die material.2 While unfavorable angulation can be corrected with the restoration, the lack of parallelism in implants and the presence of undercuts creates an undesirable path of placement that may distort the impression material upon removal and may produce an inaccurate master cast, especially when multiple implants are used.3 Many studies found that increasing the divergence or convergence of implants had detrimental effects on impression accuracy. However, some studies found no differences between the impression accuracy of different implant angulations.[4]

The objective of this article is to review the evidence-based literature on implant impression accuracy and establish the current status on the best practice with regards to angulated implant impressions, based on the data.

II. Material and methods:

Electronic searches were performed in MARCH 2018 from MEDLINE, EMBASE, and Cochrane Library databases with the key words implant, angulated implants, implant impression, and impressions. No publication year limit was used, so that the search could include the first available year of the particular database to March 2018.

The abstracts of the articles were retrieved, reviewed, and sorted based on the following inclusion and exclusion criteria. To be included in the study, the article had to be published in an English peer-reviewed journal and be an experimental study investigating the accuracy of implant impressions. Excluded were the following: clinical or technical reports simply describing a particular material Or technique, structurally incomplete publications such as abstracts only, and review articles. In addition, a hand search of the following journals was performed to enrich the results for the time period from January 1991 to March 2018: The Journal of Prosthetic Dentistry, The International Journal of Oral and Maxillofacial Implants, The International Journal of Prosthodontics, Implant Dentistry, The International Journal of Periodontics and Restorative Dentistry, Journal of Prosthodontics, Clinical Oral Implants Research, and Clinical Implant Dentistry and Related Research. After executing the search strategies, 27 articles were selected.

III. Results:

Table 1. Studies comparing angulated implant impression accuracy: Implant angulation

Author (year)	Implant connection type	Specimen number	Implant number	Implant angulations (in degrees)	Study outcome
Carr5 (1991)	Multi-base abutment level/external connection	7	5	≤ 15	No significant differences with direct technique; indirect technique showed inaccuracy for 15-degree angulation

Carr6 (1992)	Multi-base abutment level/external connection	10	2	0 and 15	No significant differences in accuracy
WG Assuncao7 (2004)	Implant level/internal connection	60	4	0, 80, 75 and 65	Significant differences in accuracy between parallel and non-parallel implants
Conrad et Al8 (2007)	Implant level/ external connection	5	3	0, 5, 10, and 15	No significant differences in accuracy for all the three angulations. No differences between closed tray and open tray.
Choi et al9 (2007)	Implant level/internal connection	10	2	0 and 8	No difference in accuracy between 0- and 8-degree angulated implants
Assuncao et al10 (2008)	Implant level/ external connection	10	2	0 and 25	Significant differences in accuracy with 25-degree implant divergence; inclined implants caused more inaccuracy
Lee et al11 (2009)	Implant level/internal connection	10	2	0 and 10	Significant differences in accuracy with closed tray; no differences with open tray
Filho et al12 (2009)	Implant level/ external connection	6	2	0 and 25	Significant differences in accuracy with 25-degree implant divergence; inclined implants caused more inaccuracy
Jo et al13 (2010)	Internal connection	10	3	0 and 10	No differences between parallel and non-parallel implants for 10-degree divergence
Sorrentino et al14 (2010)	Implant level/internal connection	20	4	10	Significant differences in accuracy between parallel and non-parallel implants, with 10-degree angulation
Gallucci et Al (clinical study)15 2011	Multi-base abutment level/internal connection	11	2	≤10	No differences in accuracy for 10-degree angulation
Jang et al 16 (2011)	Implant level, internal connection	10	2	0, 5, 10,15, and 20	Significant inaccuracy (gap) when divergent angle was 20 degrees; generally, more the divergence greater the gap between framework and the abutments
Rutkunas et Al17 (2012)	Implant level/internal connection	1	2	5 and 25	Significant differences in inaccuracy for 25-degree angulation; increased angulation decreased the accuracy
Pavlos Mpikos18 (2012)	Implant level/internal Connection & external connection	4	8	0, 15, and 25	The interaction between impression technique and implant angulation was not significant in the accuracy of impressions for either external- or in Internal-connection implants.

Zerrin Fidan Akalin19 (2013)	Implant level/internal connection	18	6	0 and 10	implants placed parallel to each other exhibited greater accuracy than a model with implants placed at angles to each other
S Reddy20 (2013)	Implant level/internal connection	10	3	0,10 and 15	No significant differences in accuracy for all the two angulations. No differences between closed tray and open tray.
Balouch F 34 (2013)	Implant level/ external connection	6	3	0 and 15	No differences between parallel and non-parallel. Significant differences in accuracy with closed tray.
Aditi Prasad21 (2014)	Implant level/internal connection	10	3	0 and 75	No significant differences in accuracy for 90 and 75 degree angulations
Alexander Hazboun GB 4 (2015)	Implant level/internal connection	12	6	0, 15 and 30	No significant differences in accuracy
Tsagkalidis G22 (2015)	Implant level/internal connection	10	6	0, 15, and 25	Significant differences in accuracy with 25-degree implant divergence; inclined implants caused more accuracy
F Geramipanah23 (2015)	abutment level/internal connection	10	4	20 and 30	No significant differences in accuracy
M Vojdan 24 (2015)	Implant level/internal connection	10	4	0,20 and 30	Significant differences in accuracy with angulated implants
Reshma Babu25 (2016)	Implant level/internal connection	15	4	0, 5, 10, and 15	Significant differences in accuracy between parallel and non-parallel implants
Y Ravi Shankar 26 (2016)	Implant level/internal connection	20	6	0°, 10°, and 20	Significant differences in accuracy with open tray; no differences with closed tray
Schmidt 27 (2017)	Implant level/internal connection	10	6	0,15 and 20	Significant differences in accuracy between parallel and non-parallel implants
Saboury A. et al.28 (2017)	Implant level/internal connection	5	2	15	Significant differences in accuracy with closed tray (indirect) technique
EA Elshenawy29 (2018)	Implant level/internal connection	10	3	0,15 and 30	implant angulation increased from parallel implants to 30°, the forces of deformation increased, which resulted in increased distortion.

Implant angulation:

Of the 27 studies, most of the studies evaluating the effects of implant angulation had done so with three to eight number of implants 4,5,7,8,13,14,18,19,20,21,23,24,25,26,27,29,34 & except for a few papers which studied the effect with two number implants 6,9,10,11,12,15,16,17,28. One was a clinical pilot study15. Hence, a correlation was seen between increased number of implants and impression inaccuracy even for minor angulations.

Nine studies 4,6,8,9,13,18,20,21,34 found no significant differences between parallel and non-parallel implants, fourteen studies7,10,11,12,14,16,19,22,24,25,26,27,28,29 found significant differences in accuracy between parallel and non-parallel implants. Five studies 5,14,15,17,28 that found significant differences at 10 , 15 and 25 degrees divergence. One study23 found no significant differences in accuracy up to angulations of 20 and 30 degrees.

Clinical factors affecting the implant impression accuracy:

Table 2.Studies comparing the angulated implant impression accuracy: transfer Vs pickup impression

Techniques

Study	Result
Jo et al[13], Carr[5], Lee et al11, Rutkunas et al[17], Aditi Prasad[21] , Y Ravi Shankar[26] , EA Elshenawy[29]	Pickup (open tray, direct) more accurate than transfer (closed tray, indirect)
Saboury A. et al.[28], Balouch F [34]	Transfer (closed tray, indirect) more accurate than pickup (open tray, direct)
Carr6, Conrad et a[18], Gallucci et al15 (clinical study), Alexander Hazboun GB [4] , Pavlos Mpikos[18]	No significant differences between pickup and transfer

Impression techniques: pickup vs transfer

Fourteen studies4-6,8,11,13,15,,17,18,21,26,28,29,34 compared the differences between pickup and transfer impression techniques for angulated implants in terms of accuracy (Table 2). Of the 14, 7 studies 5,11,13,17,21,26,29 concluded that pickup impressions were significantly more accurate than transfer, and five studies 4,6,8,15,18 showed no statistically significant differences between the two

techniques. The evidence base supporting transfer over the pickup technique was negligible28, 34. For situations in which there were 3 or fewer implants, most studies showed no difference between the pickup and transfer techniques, whereas for situations in which there were 4 or more implants, most studies showed more accurate impressions with pickp technique than the transfer technique.

Table 3.Studies comparing the angulated implant impression accuracy: splinting Vs non splinting Techniques

Study	Result
Filho et al[12], Saboury A. et al[28]., Y Ravi Shankar[26], WG Assuncao[7] , G Tsagkalidis[22], EA Elshenawy[29]	Splinting significantly better than nonsplinting
Lee et al[11], Choi et a[9]	No significant differences between splinting and non-splinting
Assuncao et al10	Non-splinting significantly better than splinting

Splinting Vs non-splinting:
All the selected articles were in vitro studies. Nine studies 7,9-12,22,26,28,29 compared accuracy between the splint and non-splint techniques (Table 3). Of the nine studies, six studies 7,12,22,26,28,29 found splinting significantly better than non-splinting. Only one study10 supported non-splinting over splinting and two studies 9,11 found no significant difference between splinting and non-splinting.

From the above literature it is found that further studies are require to access the effect of splint technique on accuracy of impression.

Table 4.Studies comparing the angulated implant impression accuracy: Impression material

Study	Result
Sorrentino et al[14]; Lee et al[11], M Vojdan[24] , A Schmidt[27]	PVS more accurate than PE,VSE
Zerrin Fidan Akalin[19]	PE more accurate than PVS
Rutkunas et al[17] , S Reddy[20]	No significant differences between PVS and PE
Y Ravi Shankar[26]	VSE more accurate than PE & PVS
WG Assuncao[7]	PVS & PE more accurate than P

*PVS- polyvinyl siloxane, PE-polyether, VSE-vinylsiloxane ether, P-polysulfide

Impression materials:
Very few studies have examined impression material as a factor affecting angulated implant impression accuracy. of the nine studies 7,11,14,17,19,20,24,26,27 (Table 4) , four studies11,14,24,27 found polyvinyl siloxane better than polyether and vinylsiloxane ether. Two studies 17,20 found No significant differences between Polyvinyl siloxane and Polyether. One study19 supported Polyether over polyvinyl siloxane. One study26 examined the new impression material Vinyl siloxane ether and found more accurate than polyvinyl siloxane and polyether. WG Assuncao7 found poly vinyl siloxane and polyether more accurate than polysulfide.

I. Discussion:
The primary purpose of this review was to compare the accuracy of angulated implant impressions. Most of the assessed studies were in vitro and mainly examined four clinical factors affecting implant angulation ,impression material, impression technique (open tray or closed tray), and splint or nonsplint On analysis of the data, a recent increase in the publication of articles related to implant impression accuracy was noted.

Implant angulation: Regarding implant angulation, 27 studies 4-29,34 examined the effect of implant angulation on the accuracy of impressions. 9 studies found no significant differences between parallel and non-parallel implants, 14 studies found significant differences in accuracy between parallel and non-parallel implants. 5 studies that found significant differences at 10 , 15 and 25 degrees divergence. One study found no significant differences in accuracy up to angulations of 20 and 30 degrees.

Impression techniques: pickup vs transfer: The scientific evidence on the accuracy with pickup (direct, open tray) vs transfer (indirect, close tray) impression techniques was based on 14 in vitro studies 4-6,8,11,13,17,18,21,26,28,29,34 except one(clinical study) 15 and supports (14 studies, 7 open-tray; 2 closed-tray ; 5 no difference) open-tray implant impression techniques Splinting Vs non-splinting: The scientific evidence on splinted vs non-splinted techniques relied on 9 in vitro studies 7,9-12,22,26,28,29 and supports (9 studies,6 splint; 1 nonsplint; 2 no difference) the technique of splinting the impression copings for implant impressions.

Impression materials: The scientific evidence on the accuracy of impression techniques with different impression materials relied on 9 in vitro studies 7,11,14,17,19,20,24,26,27, and supports Polyvinyl siloxane and polyether (9 studies, 2 no difference between PVS & PE ; 4 PVS more accurate than PE & VSE, 1 VSE more accurate than PE & PVS, 1 PVS & PE more accurate than P, 1 PE more accurate than PVS). Various impression materials were tested but polyvinyl siloxane and polyether both are the material of choice for making accurate impression.

Other factors which may affect the accuracy of angulated implant impression are:

Studies reported the effect of various factors on the accuracy of implant impression such as implant level 32,, abutment level 33,23 , impression tray 30, depth of implant31, time duration between impression making and stone pouring.[32]

Implant connection type: 19 studies 4, 7, 9, 11, 13, 14, 16, 17, 19-29 (Table 1) estimated impression accuracy with internal connection implants, and 4 studies 8,10,12,34 with external connection. Impressions were made at the implant level with impression copings in most of the studies, except a few 5, 6, 15,18 where intervening multi-base abutments were used and abutment level impressions were made with the impression copings fitted onto the abutments.

II. Conclusion:
Within the limitation of this study, the conclusion based on literature review are:
1) For internal and external implant connections, implant angulation seems to have a negative effect on the multi-unit implant impression accuracy, more so with increased divergence.

2) Pickup impression technique is better than the transfer technique for producing accurate Impressions of angulated implants, especially with increased numbers of implants.

3) Polyvinyl siloxane and polyether are the material of choice for making accurate impression in parallel as well as angulated implants among which polyvinyl siloxane gives more accurate impression.

4) Splinting of impression copings produce more accurate impression in multiple angulated implants.

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