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RESEARCH ARTICLE

COMPARISON OF THREE-DIMENSIONAL (3D) ACCURACY BETWEEN CONVENTIONAL AND DIGITAL IMPRESSIONS FOR MULTIPLE IMPLANTS SUPPORTED PROSTHESIS:AREVIEW

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Abstract

One of the most dramatic transformations in the field of dentistry has been the embrace of modernized computer-aided design(CAD) and computer-aided manufacturing(CAM)dentistry. Today, innovative dental offices can leverage these technological advancements in the dentistryto make the tooth restoration process more efficient, cost-effective, and accurate, all of which can lead to better patient experiences and outcomes.Digitalimpressions can simplify and improve the impression process. The use of digital impressions has gained more popularity due to the production of comparable precise models and reduction of the digital workflow process.Thisreview article explores various techniques used for conventional and digital impression and to compare the 3Daccuracy of conventional and digital impression techniques for multiple implants in edentulous areas.

Introduction:-

Cad cam has gained increased popularity in implant dentistry in last 15 years. The introduction of Cad-Cam technology has made it possible to scan and create a 3D digital image using intraoral scanners,of a tooth preparation or implant, which then can be used to design and fabricate a restoration.

Intraoral scanners have radically changed the way in which the dentists approach the restorative workflow. In prosthodontics, intra-oral scanning has simplified the impression procedure by reducing the number of production steps. This improves the precision, reduces the treatment time, and finally leads to a better fit of the restoration. The constant evolution of the hardware and software in relation to this has made a digital end-to-end restorative solution a reality. Precision, accuracy, and hassle-free procedures have made these systems user-friendly and patient friendly.

Goals Of Implant Impression

An advanced planning is always critical to making an implant impression, also an accurate impression is vital in giving the patient a successful prosthesis which resembles the appearance and function of the natural tooth. The goal of constructing impression in implant dentistry is tocapture the position of osseo-integrated implant fixture accurately,associating it to surrounding structure for fabrication of a superstructure with optimal aesthetic emergence profile and management of soft tissues surrounding the implant fixture.

Classification Of Conventional Implant Impressions

The techniques for implant impressions are classified on the basis of:

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1.By Impression level:
a. Fixture level Implant Impression: The impression coping is connected to the top of the implant fixture (body of the implant).
b. Abutment level Implant Impression: Abutment level impression is a method of taking an impression by connecting the abutments to the top of the implant fixture (body) and subsequently connecting the impression copings to them.

2. The type of tray used or Impression coping:
a. Open-tray (Pick-up) Impression: The open tray impression technique is one of the commonest impression methods used. This method helps in connecting the impression coping to the fixture in the oral cavity. The open tray technique reduces the effect of implant angulation, deforming the impression material upon recovery from mouth, and removes the extra concern of replacing the copings into the impression.
b. Closed-tray (Transfer) Impression: The impression copings for a closed tray technique are placed on implants or multi-unit abutments and the impression are made. Furthermore, the impression copings are removed, and implant or abutment analogs are attached to the copings. This then goes into the impression body during what is called a transfer process. The combined coping-analog assembly is then inserted into the definitive impression.

Digital Impressions
With the expanding use of digital/computerized impressions, implant systems provide scan bodies that allow for capture of the relationship of the implant connection to adjacent structures more accurately through sensors. This negates or reduces the use of traditional impression materials [1]. The necessary needs for the CAD/CAM are the -
(a) the digitalscanner (intraoral or extraoral), which scans and converts the geometry of the tooth into data that is read by the computer,
(b) a software that acquires the data and changes into a 3D model,
(c) a production technology that transforms the data set into thedesired product by means of CAM.

Fig.1:- Illustration of the polygon meshes formed during the digital 3D object reconstruction process.

Courtesy of 3M ESPE Germany GmbH

The foremost common scanning principles utilized by intraoral dental scanners are triangulation, active wave-front sampling, and parallel confocal optical device scanning.

Triangulation
Triangulation is based on a principle that the position of a point of a triangle (the object) can be calculated knowing the positions and angles of two points of view. These two points of view may be produced by two detectors, a single detector using a prism, or captured at two different points in time.

Confocal
Confocal imaging is a technique based on acquisition of focused and defocused images from selected depths. This technology can detect the sharpness area of the image to infer distance to the object that is correlated to the focal length of the lens. A tooth can then be reconstructed by successive images taken at different focuses and aperture values and from different angles around the object. The sharpness area is directly related to the dexterity of the operator who can generate motion blur, and this technique also requires large optics that may lead to difficulties in clinical practice.

AWS (Active Wavefront Sampling).
AWS is a surface imaging technique, requiring a camera and an off-axis aperture module. The module moves on a circular path around the optical axis and produces a rotation of POI. Distance and depth information are then derived and calculated from the pattern produced by each point.

Stereophotogrammetry.
Stereophotogrammetry estimates all coordinates (x, y, and z) only through an algorithmic analysis of images. As this approach relies on passive light projection and software rather than active projection and hardware, the camera is relatively small, its handling is easier, and its production is cheaper.

Reconstruction Technologies
One of the major challenges of generating a 3D numerical model is the matching of POI taken under different angles. Distances between different pictures may be calculated using an accelerometer integrated in the camera, but a similarity calculation is more often used to determine the point of view of the image. Using algorithms, similarity calculation defines POI coincident on different images. These POI can be found by detection of transition areas, such as strong curvatures, physical limits, or differences of grey intensity ("Shape from Silhouette"). A transformation matrix is then calculated to evaluate similarity between all images such as rotation or homothety. Extreme points can also be statistically eliminated to reduce noise. Each coordinate (x, y, and z) is extracted from the projection matrix, and a file is then generated. [2]

Definition of IOS Accuracy
According to ISO 5725, the accuracy is described by two measurement methods: trueness and precision. Trueness refers to the closeness of agreement between the arithmetic mean of a large numberof test results and the true or accepted reference value. Precision refers to the closeness of agreement between test results. The method of measurement contributes to the variability of trueness and precision reported for IOS, as this depends on aspects such as the operator, equipment used and calibration, the time elapsed between measurements, and the environment (temperature, humidity, etc).[3]

Conventional Vs Digital Impressions
To fabricate a prosthetic framework on multiple implants, fabrication of an implant-borne superstructure that passively fits is fundamentally important. A recent study described the range of acceptable 3D clinical misfit forone-piece implant prosthesis as 56 to 72 μm. Jemt suggested that prosthesis misfits smaller than 150 μmare acceptable.[4] Errors in conventional impressionsmay be introduced by inadequate impression tray selectionand preparation, limitations in the impression materialflow and hydrophilicityorimproper procedures and timing for impression handling and pouring[5].Moreover, if the implants are tilted at different angles, performing a highly accurate conventional impression may be challenging as the distortion of the impression material, i.e. the elastic recovering potentiality is exceeded within the highly applied forces during the disconnection and removal of the impression (Mpikos et al., 2012). [6]

Fig. 2:- Conventional multi- implant impression of a master cast simulating jaw with 4implants.
[Courtesy:Gintaute A. et al]

Studies have shown that digital implant scan accuracy may be influenced by implant angulation, inter-implant distance, implant depth and operator experience.Additionally, the scan body shape and design may also influence the accuracy of the digital scan.[7]

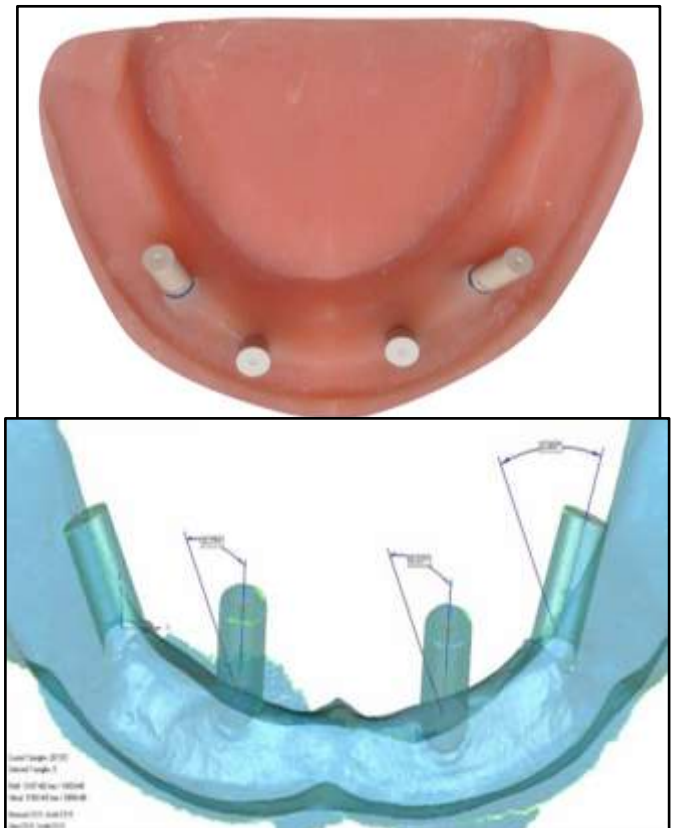

Fig. 3:- Digital impression made using scan bodies of a master cast simulating jaw with 4implants.
[Courtesy: Gintaute A. et al]

A systematic review and meta-analysis of vertical marginal fit in controlled in vitro studies by Russoet al concluded that no statistically significant differenceswere present in thevertical marginal fit of tooth-supported or implantsupportedMFDPs fabricated using digital or conventional techniques.[8] A comparative in-vitro study done by Menini et al. on a master cast simulating jaw with 4 implants, digital impressions showed better accuracy than

with a mean gap of 0.015±0.011 mm compared to 0.022±0.023mm mean gap in conventional impressions.[8]In another in-vitro study performed by Drancourt et al comparing accuracy in different digital scanners (CS3600, Primescan, i500, Trios 4) and conventional method observed that conventional methods had lower mean absolute distance deviation and direction of the distance deviation from the reference digital model and were the most accurate whereas 4 scanners provided variable results.[9]

The scientific research on the combined use of digitalimpressions with CAD/CAM (computer aided design/computer-assisted manufacture) techniques for thefabrication of multi-unit implant restorations is at apreliminary stage. Very few accuracy studieshave been reported on the use of intraoral scannersand laboratory scanners to record 3D dental implantpositions using scan bodies and/or digital coded healingabutments.

Conclusion:-

Concerning implantology, various in vitro studies concluded that triangulation, confocal and AWS technologies used for digital impressions can be a feasible alternative to high-accuracy scans currently used for scanning conventional impressions or plaster models.Much of the current available evidence in the area is in vitro in nature and clinical studies are required to validate the results obtained from the laboratory studies.As digital technology constantly evolves and companies are trying to catch up with new products, such as IOSs, 3D printers and other components for digital applications, it can only be assumed that improvements will be made, and further innovation will be available.

Conflicts of Interest

The authors declare that there are no competing interests.

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