Impression of multiple implants using photogrammetry: Description of technique and case presentation

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Abstract

Aim: To describe a technique for determining the positions of multiple dental implants using a system based on Photogrammetry, CAD/CAM.

After processing patient and implant data, special abutments (PICabutments®) are screwed onto each implant. The PICcameras® were then used to capture images of the positions, automatically taking 150 images in less than 60 seconds. From this image analysis, the software was able to obtain a 3D model of the patient’s mouth, with optimal fit. The pros thesis was verified in the patient’s mouth using the Sheffield test and the screw resistance test.

Results and Conclusions: Twelve months after loading, peri-implant tissues were healthy and no marginal bone loss was observed.

The clinical application of this new system using photogrammetry has been presented. In this case, multiple dental implants facilitated the rehabilitation of a patient with posterior maxillary edentulism by means of a prosthesis with optimal fit. The prosthetic process was accurate, fast, simple to apply and comfortable for the patient.

Keywords: Dental implants, photogrammetry, digitization process, CAD/CAM.

Introduction

Dental implants are one of the most widely used therapies for the rehabilitation of partially or completely edentulous patients. It is scientifically proven that achieving proper osseointegration of the implant-supported prostheses improves the long-term prognosis of this therapy (1,2).

The classic system for fabricating implant-supported prostheses involves waxing up the model, and after placement of the implant analogues, subsequent casting in plaster to make impression. In order to achieve an adequate passive fit of the prosthesis, a trial fit must be obtained to correct registration of the three-dimensional position of the implants (3). Conventional impression techniques use abutments that, screwed onto the implants, capture the anatomic platform and en compassed by setting material, should register and transfer the spatial position of the implant. These methods involve time-consuming clinical work and the use of impression materials and techniques that often fail to achieve a perfectly accurate master cast. Moreover, these techniques are generally un－pleasant for the patient (7,8).

In this literature review, the increasing application of digital techniques at different stages of dental implant therapy (9) is described. At the stage when impressions are taken, intraoral scanners are being introduced into clinical practice. The technique avoids the need for registering implant positions with impression materials and plaster model making so that the efforts involved in using these materials can cause unnecessary stress when it comes to reproducing intraoral dimensions (7,10-12). These instruments are a promising alternative for obtaining intraoral impressions in a fast and comfortable way for the patient. However, they are not indicated for all rehabilitation requirements requiring more than 5.4 pieces.

Photogrammetry is a novel option for reliable, direct intraoral registration of the positions of multiple implants. It is a tech－nique used to determine the geometrical properties of objects and their spatial arrangement from photographic images. Its most important feature is the precision with which it can measure objects without direct contact.

Photogrammetry is useful in many sciences and fields. It has been applied mainly to topogra－phy, but there are many non-topo－graphic applications, including different areas of medicine such as radiology (to improve accu－racy), surgery (neurosurgery, plastic surgery, sinus surgery) or rehabilitation (15,14).

In dentistry, this technique has been used to study the shapes and positions of teeth, dental arches and maxillary and mandi－bular bones. In orthodontics, it allows the three-dimensional analysis of the variations of the palate while performing rapid palatal expansion techniques and evaluating the achieved dental movement (15-18). Re－cently, its application in dental implant surgery planning has also been reported (19).

In the field of implant dentistry, it has been used to check the ac－curacy of other impression tech－niques, by analyzing the differ－ences between digital models obtained using different techniques and materials (20). As long ago as 1999, Jentz and Black (21) pro－posed photogrammetry as an alternative to conventional im－pression techniques. However, no research was undertaken then on development of this applica－tion has been reported. The most important quality of this technology - measurement accuracy - is the key to success in implant impressions.

Therefore, its application may be a very useful technique that will improve dental implant therapy.

The aim of this report is to de－scribe this technique applied to register the position of multiple dental implants using a system based on photogrammetry. A case is presented in which a prosthetic treatment was per－formed successfully using this technique.

PICcameras®

The PICcameras® (PICDental, Madrid, Spain) is a stereocam－era that records implant posi－tions in the mouth by means of photogrammetry. It comprises two CCD cameras specially de－signed to observe implant positions with impression use, which accurately determine the position of the implants by using the positions and the spatial orientation of the identification of abutments screwed on implants with unique individual coding (PICabutments®, PICDental).

The camera has an infrared flash that constantly illuminates the scanned object while elimin－ating the shadows that occur with ambient light. The PIC－camera® processes the images of two three-dimensional photographs for every two PICabutments®. To do this, it automatically takes ten extraoral pictures per sec－ond with an error of less than 10 microns in the diameter and distances between implants are interrelated and treated as a unit.

System software calculates av－erage angles and distances between implants from these photographs, obtaining an ac－curate relative position of each implant. This data is in the PICfile® (PIC Dental), which contains all the information on implant positions, connections, healing abutments and screws that are later re－quired CAD/CAM software.

Clinical Procedure

A 55-year old male with no rel－evant medical history came to the Oral Surgery Unit of the University of Valencia request－ing the rehabilitation of hir－dentulous right maxillary poste－rior region with dental implants. After checking the presence of enough residual alveolar bone height, by means of a panoramic radiograph, three Euroteknika® (Euroteknika Ibérica, Barcelona, Spain) implants were placed of 4.1 mm in diameter (Fig. 1). Three months later, the position of the implants was registered using the PICcameras® (PICDental).

Firstly, the patient’s demo－nal references, and the prosthetic pro－grams were created. The specific geometry of the implant connections was also scanned, entered in the Sheffield test. After aligning the abutments and placing an alginate im－pression was taken and cast in plaster. The plaster model was scanned with a 3D scanner in an open STL format to obtain infor－mation regarding the patient’s soft tissues (Fig. 1). This infor－mation was then introduced in the CAD software together with the PICfile®.

The PICfile® and the digitized plaster model were aligned with the Exocad® software (Exocad GmbH, Darmstadt, Germany) using three-point registration and subsequently improved alignment by Best-fit® (Fig. 1). This process transferred the relative position between im－plants to the digital model which provided the shape of the soft tis－sues, thus leaving the interfaces of the future prostheses in rela－tion to the patient’s gingiva (Fig. 1). A model of the antagonist arch was also scanned and centered in the CAD software to provide occlus－al references, and the prosthetic structure was designed using Exocad® (Exocad, GmbH) in STL format (Fig. 2). The design was sent to be machined in chrome-cobalt (Cr-Co) by a five－axis milling machine (Fig. 2).

To build a working model, the digital model was processed providing the spatial geom－etries of the implant connections (Fig. 2) and it was manufactured by means of stereolithography using a 3D printer (Objet 2500® Eden, Israel). The model was processed in a manner that al－lowed the addition of false gum for further work in the labora－tory (Fig. 2).

Once the internal structure of the implant-supported fixed par－tial denture, its passive fit was checked in the patient’s mouth. The Sheffield and one-screw tests were used: a distal screw was placed at the screw 14 in this case - and a periapical radiograph was ob－tained to check the correct pros－thetic settlement on the other two implant connections (Fig. 2).

The screw resistance tech－nique was used as a subjective complementary test of the pas－sive fit. Distal screws #14 and #17 were screwed with a torque of 10 Ncm and then a medial screw was introduced verifying that the tactile sensation was soft and presented no resistance to screwing. After these verifica－tions, the Cr-Co structure was sent to the laboratory to have the ceramic loaded. The prosthesis/once finished, was screwed onto the implants (Fig. 3), with 25 Ncm torque. Occlusal adjustments were performed and the correct set－tlement on the implant connec－tions was verified with a radiograph (Fig. 3). A follow-up plan was established and twelve

Fig. 1. A) View at three months after the placement of three implants in the posterior right maxillary region; B) Individualcoring screwed onto implants; C) Digitized plaster model; D) Alignment by means of Best-fit®from the PICfile® vector file and digit－alized plaster model; E) Relative intercusp interface positions of the future prosthesis in relation to the gums.

Fig. 2. A) Upper and lower plaster models and design of the prosthetic structure; B) Mached metal structure in Cr-Co; C) Digital working model; D) Stertolithography working model with false gums; E) Check－ing the metal structure in the mouth; F) Periapical radiograph during the Sheffield test.
months after loading, the peri-
implant tissues were healthy and no peri-implant marginal bone loss was observed (Fig. 5). Discussion The provision of ten-
sion-free connections between implants and the prosthetic structures they support is a re-
quirement for both short- and long-term success of implant-
supported rehabilitations. This situation can be achieved by carrying out a prosthodontic treatment with good passive fit. Particularly so, if the dentist is performing precisely and accurately, keep-
ing the margins of error and inaccuracies at a minimum in the process to a minimum (1,22).

In vitro studies have shown that discrepancies in the super-
structure will be the cause of stress on the implant-supported prosthesis and subsequent fail-
ure. As long ago as 1986, Balshi described mechanical failures which he associated with lабo-
ratory errors that were carried out using imprecise working models. Jenett et al. (8) and Ruhamann et al. all point out that the fit between prosthesis and abutment is a key parameter for avoiding overlappings or undercuts which lead to prosthodontic failure. For this reason, the taking of im-
pressions is a key process in order to obtain structures with a good passive fit. There is some controversy in the literature as to which impression technique is the most reliable.

Recent research with conventional techniques is impo-
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sidered the open tray technique to be the most precise, 15% the reproducible (6). The greater ac-
curacy of the open tray technique was achieved by carrying out a procedure called Bite Registration. This technique avoids the in-
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pression materials. The PC-camera measures angles and distances between prosthodontic attachments placed on the im-
plants, allowing the patient to be seated by the dentist and the position of the implants to be expressed in 3D to a computer (26-28).

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