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Indirect orthodontic bonding using an original 3D method compared with conventional technique: A narrative review

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ABSTRACT

As well known success in orthodontics is related to a correct diagnosis and to a carefull treatment planning. Our study aims to provide clinician with a reproducible and precise method, for orthodontic indirect bonding, thanks to CBCT images and due to a CAD-CAM process. Methods: A case of an orthodontic treatment plan, of a female patient, 37 years old, was selected. Plaster models were digitally acquired using the Extra-Oral scanner Maestro 3D and processed within the Studio Maestro 3D software. CBCT images in DICOM format were imported into the MIMICS software, in order to perform the segmentation of the dental elements, and to obtain a three-dimensional coronal-root dental arches model. The DICOM file thus processed was exported in an STL file, reworked with Meshmixer software to improve image quality, and imported into the 3D Maestro software to be superimposed on the digital model. In this way a three-dimensional real model of the dental arches was developed. After an accurate orthodontic virtual set-up, we proceeded to brackets positioning on the 3D model of the dental arches. Subsequently, a virtual transfer template was created, in order to carry out the digital printing of a thermo-printed mask necessary to perform an indirect bonding of the orthodontic appliance. Results: The original digital workflow proposed in this study allows the development of a real and non-ideal three-dimensional coronal-root model of the dental arches; this model can be used for indirect orthodontic bonding eliminating any errors in the expression of 1st, 2nd and 3rd order information of the pre-informed orthodontic appliance. Conclusions: Technological advancements in oral scanning and 3D printing will allow the achievement of an easy and reproducible ideal positioning of the orthodontic brackets.

1. Background

Indirect orthodontic bonding is a method developed by Silverman [Silverman et al., 1972] increasingly used in the clinical practice. From an accurate review of litterature emerged that indirect bonding have several advantages if compared to the direct one such as; comfort for the patient [Burhardt et al., 2016], easy reproduction of bracket position, better adhesive performance [Sabbagh et al., 2022], and greater clinical efficiency and effectiveness thank to shorter chair-time and to the reduction of treatment duration and staff required [Nawrocka et al., 2020].

Carlson and Johnson [Carlson and Johnson, 2001] indicated four parameters that must be considered during brackets' positioning: (1) bracket base adaptation to the contour of the tooth surface, (2) evaluation of the rotational position of each bracket from the occlusal direction, (3) determination of the vertical position of each bracket, and (4) determination of the desired slot angulations of each bracket by evaluating the position of the roots.

As demonstrated by Rosti [Rosti et al., 2019] indirect digital bonding can be particularly advantageous in clinical practice, especially in cases where 3D customized lingual brackets is used.

Several studies have widely demonstrated that indirect bonding is a more reliable and accurate method than direct bonding, especially for vestibular appliances, resulting ina better expression of tip, torque, and in-out informations [Nichols et al., 2013; Kalange, 2004].

Hodge [Hodge et al., 2004] stated that the main advantage of indirect bonding over direct bonding is a reduction in the envelope of error in bracket position in each of the 3 orientations examined (vertical,

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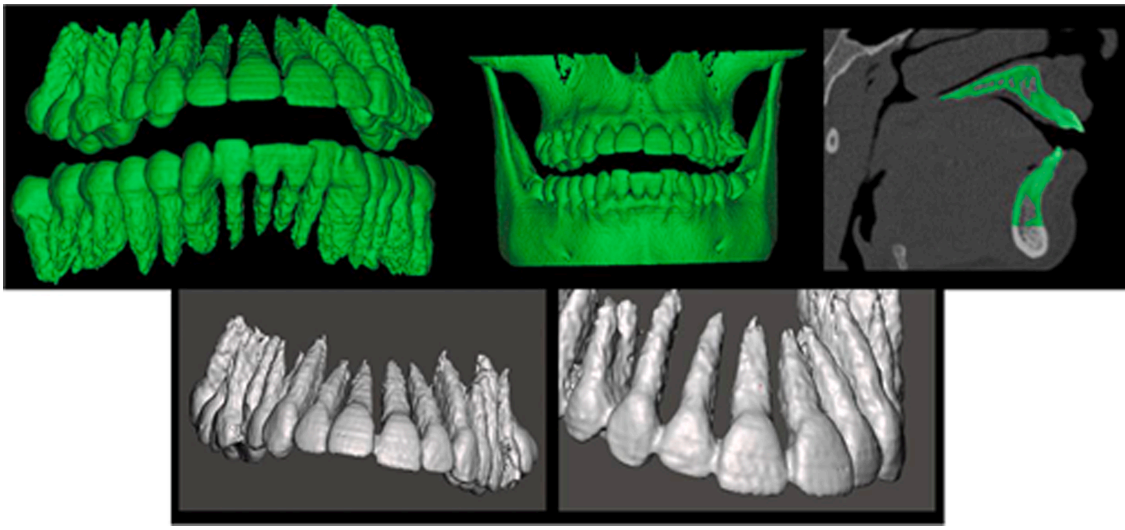

Fig. 1. 3D dental models.

horizontal, and angular).

From a review of literature is possible to state that indirect bonding have several advantages if compared to the direct one, especially in cases of straight-wire biomechanics.

Success in orthodontics is related to a correct diagnosis and careful treatment planning. Straight-wire techinques require an extremely accurate brackets positioning; during this procedure errors can be related to dental anatomy, transfer devices, adhesive procedure, clinical efficiency and patient management. The careful evaluation of all these factors will allow clinician to obtain an ideal positioning of orthodontic appliance [Grunheid et al, 2016].

Nowadays CAD/CAM, find an increasing use in orthodontic clinical practice; based on a virtual model is possible infact to design and then printing a transfer mask usefull for indirect orthodontic bonding [Kulkarni and Goyal, 2022, Kulkarni et al., 2021].

Setup models indicate only crowns' position, wihout informations on roots and bone; by now only few contributions propose the use of 3D RX and laser scan to create a 3D virtual model [Xue et al., 2020].

Roots' position control is very important in order to avoid cortical bone fenestration and-or roots' resorptions [Weltman et al., 2010]; orthodontic tretament planning should evaluate not only crowns' position but also roots' one.

Recently CBCT technology has been widely used in dentistry, as it represents a valid alternative to Computed Tomography (CT), with a significant reduction in radiation dose, costs and exposure times [Cordasco et al., 2013; Fastuca et al., 2017; Portelli et al., 2018].

CBCT can be useful in several clinical cases such as dental anomalies [Lo Giudice et al., 2017; Militi et al. 2011; Vitale et al., 2009], skeletal malocclusions, Temporo Mandibular Joint pathologies [Portelli et al., 2009, 2015], mini screw insertion [Nucera et al., 2019], assessment of growth patterns [Portelli et al., 2009], and impacted or missing teeth [Portelli et al., 2019, 2016].

Despite the significant increase of CBCT in dentistry, to date, the literature does not provide guidelines for a 3D set up model. Our study, therefore, aims to provide the clinician with a reproducible and precise method, as a tool for an accurate diagnostic framework and effective treatment planning.

2. Case presentation

The original digital work-flow proposed in this study is referred to a female patient, 37 years old, affected by third molar disodontiasis and complained of significant aesthetic discomfort related to dental malocclusion; after the first visit patient has been referred to the Orthodontics Department of the Messina University Hospital for a specialistic evaluation. Patient was considered suitable for the present study as she was

Fig. 2. Dental elements segmentation.

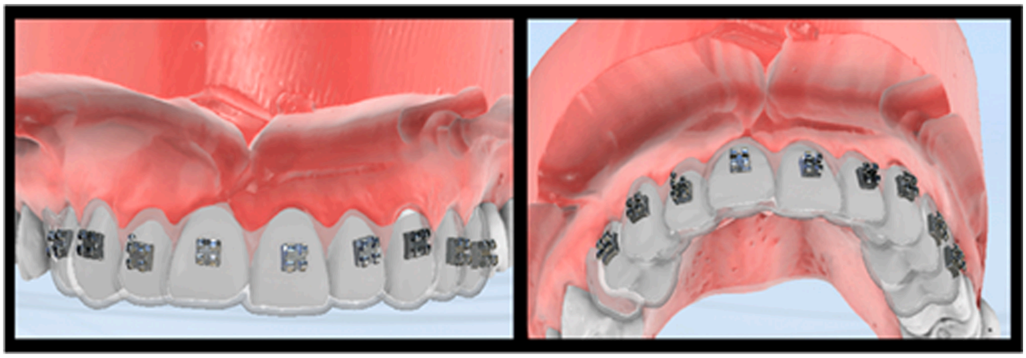

Fig. 3. Facial axis of the clinical crown evaluation.

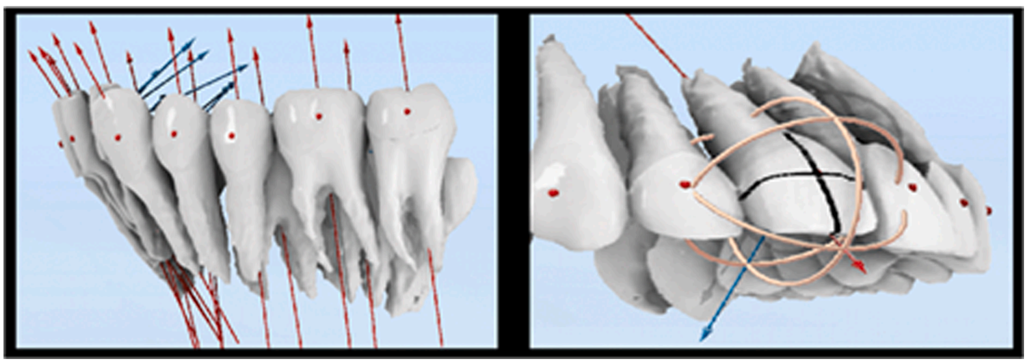

Fig. 4. Digital brackets' positioning.

affected both by dental malocclusion, susceptible of orthodontic correction, and by third molars disodontiasis, which represents a valid indication to perform a 3D evaluation, according to the ALARA principles [Portelli et al., 2016]. An informed consent for the therapy and a privacy form was acquired. At the extraoral examination, the patient presents a modest degree of facial asymmetry and a bi-protruded profile. At the intraoral examination patients show:

- Moderate bimaxillary dental crowding
- A slight deviation to the left of the mandibular inter-incisive midline
- Bilateral cuspid fand molar first-class relationship

2.1. Methodology

Silicone impressions of both dental arches were taken and an occlusal registration wax was acquired. After plaster models development, the digital acquisition was carried out using the Extra-Oral scanner Maestro 3D and processed within the Studio Maestro 3D software. A segmentation of the crowns of the dental elements and a measurement of their dimensions were performed to evaluate the Bolton index (Fig. 1).

CBCT images in DICOM format were imported into the MIMICS software, to perform the segmentation of the dental elements. The DICOM file thus processed was exported in an STL file and imported into the Meshmixer software to improve the image quality with a smooth technique (Fig. 2).

The STL file thus reworked was exported by Meshmixer and imported into the 3D Maestro software to be superimposed on the digital model.

In this way a 3D real model of the dental arches has been developed. An effective and reproducible identification of the patient's real facial axis of the clinical crown (FACC) was performed to programme a reliable virtual set-up of orthodontic dental movements (Fig. 3).

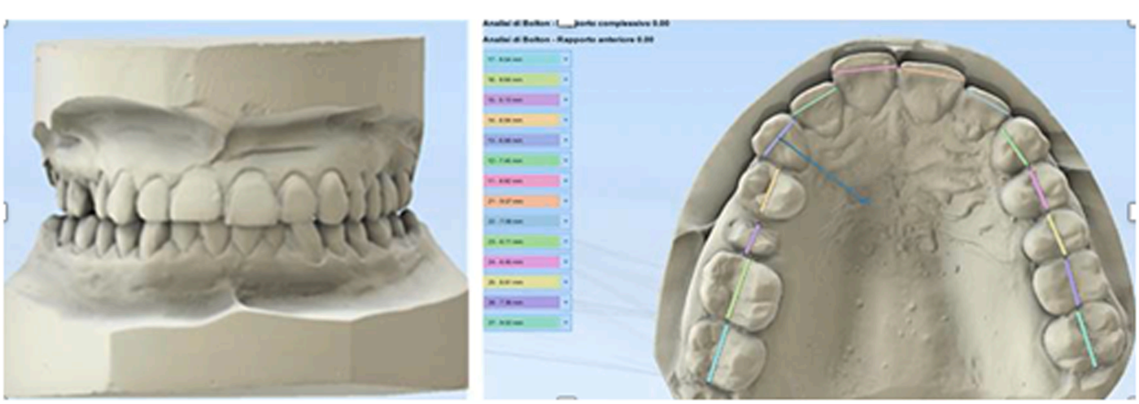

Fig. 5. Indirect bonding transfer mask.

According to our virtual treatment objectives (VTO), we have reproduced the desired tooth movements. After an accurate orthodontic virtual set-up, we proceeded to brackets positioning on the 3D models, making particular attention to the gingival soft tissues emergence (Fig. 4).

Subsequently, a virtual transfer template was created, to carry out the digital printing of a thermo-printed mask for indirect bonding (Fig. 5).

The original digital workflow proposed allows easy, effective and efficient positioning of orthodontic appliance, avoiding any positioning error.

To avoid any risk of bias in the reference list, manuscript has been checked with the Fi-index tool and obtained a score of 0.88 for the first author only on the date 28/04/2023 according to SCOPUS® [Fiorillo and Cicciù, 2022a, 2022b].

3. Discussion

Accurate bracket positioning is a key factor in orthodontics, especially in straight-wire technique; a correct positioning of the appliance minimize infact bracket repositioning or arch-wire bending [Schmid et al., 2018].

Indirect digital bonding can be particularly advantageous in clinical practice [Czolgosz and Cattaneo, 2021] but requires more extra-clinical work time and higher costs [Aksakalli and Demir, 2012]; the use of CAD-CAM systems could reduce both production costs and manifacturing defects.

The purpose of this study was to increase the synergy between indirect technique and digital programming [Wang et al., 2022] and obtain a reproducible procedure for brackets positioning [Bachour et al., 2022], based on the real anatomy of dental arches.

Real morphology and position of roots and crowns is essential during orthodontic treatment planning, to correctly program orthodontic tooth movements; it allows infact a precise and reproducible identification of the facial axis of the clinical crown that is an essential step to avoid the inadequate expression of tip, torque and in-out [Fontana et al., 2021; Sambataro et al., 2019; Militi et al., 2020; Troiano et al., 2018; Sortino and Cicciù, 2011; Lo Giudice et al., 2012].

4. Conclusions

The original digital workflow proposed in this study allows:

- Development of a real and non-ideal 3D model of the dental arches.
- Correct and reproducible identification of the FACC.
- Elimination of any errors in the expression of 1st, 2nd and 3rd order information.
- Evaluation in the virtual set-up phase of any coronal-root interference.

In conclusion, technological advancements in oral scanning and 3D printing will allow the achievement of an easy and reproducible ideal positioning of the orthodontic brackets.

Future prospects are to standardize the method in order to be simplified and reproducible even to orthodontists not so well trained.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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