

# Digital Dentistry

## Comparison between a crown based and a tooth based virtual orthodontic set-up technique

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**Aim:** Due to the rapid growth in fully customized orthodontic appliances use, principally transparent aligners but also lingual braces, virtual orthodontic set up is now commonly used in orthodontic diagnostic process and treatment planning. Software for digital set up allow to visualize only dental crowns and this could be a limit, compared to traditional stone models set up that keep the alveolar process as a reference for an accurate evaluation of bone boundaries during orthodontic movements planning. The aim of this study is to evaluate if a CBCT based digital set up, visualizing entire teeth within alveolar bone, lead to significant changes in virtual treatment planning.

**Methods:** 20 patients with class I molar relationship and slight to moderate frontal teeth crowding, according to Little's index of discrepancy, were consecutively evaluated by the same orthodontist which prepared for each one a crown based virtual set up using the 3Shape OrthoAnalyzer™ software (t0). After 1 month (t1) the same operator prepared on the same patients a tooth based virtual set up obtained using composite virtual models of entire teeth and checking them on their respective CBCT exams. Extrusion, intrusion, angulation, and inclination correction's values for each single tooth were recorded and, after testing data distribution with Shapiro-Wilk and Levene tests, paired t-test was used to identify differences. Five models were randomly selected and re-examined by the same investigator after an interval of 3 months: intraclass correlation coefficient (ICC) of absolute agreement for each measurement was used to assess

intra examiner reliability.

**Results:** Both statistically and clinically significant differences were found with regard to angulation and inclination correction's values in the anterior teeth, and with regard to inclination correction's values in the posterior teeth. The intra-operator reproducibility study showed mean ICC coefficients ranging from 0.778 to 0.889.

**Conclusion:** The use of fully individualized appliances for treating orthodontic patients could reduce working chair-time during the treatment but it is very important to accurately plan and evaluate the final occlusion programmed with the virtual set-up because clinically significant differences could appear especially if the set-up is performed using dental crown only without the support of a reference bone boundaries system such as a CBT exams of both arches.

## A new methodology for the evaluation of digital implant impression for full-arch

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**Aim:** The aim of the present study was to introduce a new method to evaluate the accuracy of digital impression for full-arch implant-supported fixed dental prosthesis.

**Methods:** A virtual model of a mandibular edentulous with six scan-abutment positioned vertically at different height was designed by software (CAD) and subsequently manufactured in zirconia by a

CNC machine tool (master model). The master model was measured with a coordinate measuring machine (CMM) (SmartScope Flash). The coordinates of the probed points were transferred into a 3D CAD software (Rhino 5.0 Beta) and analyzed with a task specific evaluation protocol to estimate the position and orientation of each scan-abutment. The measuring system is capable of a maximum permissible error (E, in micron) that is 10 times lower than both the performance of scanners commonly used in framework digital manufacturing and the expected position errors of the scan-abutment surfaces:  $E1(z) = 2.5 + 5L/1,000 \mu\text{m}$ ,  $E2(xy) = 1.8 + 5L/1,000 \mu\text{m}$ ,  $E3(xyz) = 2.8 + 5L/1,000 \mu\text{m}$  (with L, in millimeters, equal to the measured distance, according to International Organization for Standardization norm 10360). The master model was directly digitized using five different intraoral scanner (n=15 for group) (Scan A, Scan B, Scan C, Scan D, Scan E). The STL file of the digital impression was sent to Geomagic Studio Software to clean the mesh from portions not related to the research and after the STL file was sent to 3D CAD geometric modelling software (Rhino 5.0 Beta). The software called "Scan-abut" was realized as a plug-in for Rhino 5.0. The software "scan-abut" selects automatically the major surfaces of the scan-abutment (cylindrical and plan area) using curvature analysis. To evaluate the positional accuracy of each impression, the estimated reference points of the were aligned, using a least-square best fitting algorithm, to the corresponding scan-abutment on the master model; the algorithm "optimizes" the position and orientation of the impression while considering the 3D distances between each scan-abutment and the relative scan-abutment on master model. Three-dimensional distances between reference points of digital impression and reference points of master model along the x-, y-, and z- axes were calculated at each position for all impression. The Wilcoxon matched-pairs signed-rank test (one-tailed) was used to compare groups. The level of statistical significance was set as  $\alpha = 0.05$  and with a statistical power of 80%.

**Results:** Statistical significant differences were found between groups. The mean 3D deviation value respect the master model (trueness) was  $31.5 \mu\text{m}$  (SD  $8.9 \mu\text{m}$ ) for Scan A,  $31.7 \mu\text{m}$  (SD  $5.1 \mu\text{m}$ ) for Scan B,  $71.3 \mu\text{m}$  (SD  $55.0 \mu\text{m}$ ) for Scan C,  $365.5 \mu\text{m}$  (SD  $143.5 \mu\text{m}$ ) for Scan D and  $107.5 \mu\text{m}$  (SD  $28.1 \mu\text{m}$ ) mm for Scan E. There was no statistically significant difference between Scan A and Scan B (p-value = 0.47), but a significant difference was present between all the groups.

**Conclusions:** Based on the results of this in vitro study, the Scan A and the Scan B demonstrated the highest accuracy. Three intraoral scanner device did not achieve the necessary level of accuracy to be used for

full-arch implant-supported fixed dental prosthesis.

### Spectrophotometric aesthetic performance of Icon treatment by deep infiltration: a case report

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**Aim:** Icon proved to be effective on enamel hypomineralized lesions on the buccal side of aesthetic tooth. Resin infiltration treatment increases the Refractive Index (RI) of demineralized enamel. Paris et al. described the rising of RI on infiltrated lesions, that took on the appearance of the sound surrounding enamel (1). Our group described the clinical efficacy of resin infiltration on White Spot Lesion (WSL), Developmental Defects of Enamel (DDE) and mild cases of Fluorosis (2) (3). On the other hand, lesions with deeper configuration in the enamel layer such as Molar Incisal Hypomineralization (MIH), hypomineralization of traumatic origin, and severe cases of Fluorosis did not seem to have the same response to Icon treatment.

The aim of this study was to present the clinical procedure of deep infiltrative technique as described by Attal et al., in a post traumatic case and the spectrophotometric objective documentation allowing the objective evaluation of the aesthetic outcome (4).

**Methods:** The study was performed at Sapienza University, Rome, Italy.

The patient, a 15 years old female, who was found with a hypomineralized lesion of traumatic origin on the upper right central incisor.

Spectrophotometric (SpectroShade, MICRO, Serial N HDL1407, MHT, Arbizzano di Negrar, Verona, Italy) and photographic images (Nikon D7100, 105 mm Macro lens, R1C1 Macro flash) were taken before and after treatment, in order to evaluate and calculate the colourimetric difference after treatment and to compare the aesthetic outcome of the treated incisor with the symmetrical one on the left side. Spectrophotometric variables  $\Delta E$ ,  $\Delta L^*$ ,  $\Delta a^*$ ,  $\Delta b^*$  were evaluated, as described by the CIE-L\*a\*b\* system, and correlated with human eye perception thresholds. Icon deep infiltration clinical procedure were performed according to Attal et al., and the clinical steps are described in Figures (1-7).

**Results:** The photographic images show the pleasant aesthetic outcome of the treated lesion, observed on the incisal section of the right upper incisor.

The colourimetric shift after treatment was evaluated by the spectrophotometric assessments taken before and after Icon deep infiltration. A  $\Delta E$  value of 5.24

with: a decrease in tooth lightness ( $\Delta L^*$ : -4.95), an increase in tooth redness ( $\Delta a^*$ : 0.25) and an increase in tooth yellowness ( $\Delta b^*$ : 1.7) were evaluated. When the treated incisal tooth section was compared to the sound incisal tooth section on the opposite side, the before existing colour difference of  $\Delta E$  value (4.55) showed a significant decrease after treatment ( $\Delta E$ : 1.02).

**Conclusion:** Icon clinical procedure proved to be effective on hypomineralized lesions with superficial configuration in the enamel layer. On the other hand, the clinical indication for lesions presenting a deeper configuration were ceramic veneers. This clinical case reports on the efficacy of deep resin infiltration performed on enamel hypomineralized lesion of traumatic origin.

### Experimental study on the evolution of the dental arch form: ancient and modern man compared by methods of measuring through 3D software

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**Objective:** The purpose of this study is to investigate the differences between ancient and modern shape of the arch form. In particular differences regarding the displacement of the dental elements with respect to the midline, the transverse width of the arches and the thickness of the vestibular cortical.

**Methods:** the two working groups formatted respectively by 9 patients from Abruzzo and 9 skulls unearthed near Opi dating from 200-300 BC, were compared with measurements made on the software "3D-DolphinImaging Dolphin & managementsolution". The differences between the two groups of values have been reported in terms of mean, standard deviation and median. Then it applied the T-Student test, supported and validated by ANOVA.

**Results and conclusions:** this study shows that, in the course of the centuries, in the Abruzzo population the upper jaw and the lower jaw had contracted. The upper jaw has have a greater contraction compared to the lower jaw and this would explain the development trend of the third class in the Abruzzo population. As regards the vestibular thicknesses, from this study there are no significant variations between the two groups considered, although it is evident tendency to the reduction in the thickness of the vestibular bone in the patients group that has the average values always lower than the Opi group. These values give no statistic certainties.

### Accuracy and precision of an intraoral scanner in

### complex prosthetic rehabilitations: case reports

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**Aim:** The aim of this study is to present two clinical cases of full arch prosthetic rehabilitations on implants and natural teeth realized using a digital work-flow to test levels of accuracy and precision of digital intraoral scanners.

**Methods:** Patients were visited at the Department of Oral and Maxillofacial Sciences of "Sapienza" University of Rome for a fixed prosthetic and implant rehabilitations. All patients agreed to treatment and signed the informed consent form, according to the World Medical Declaration of Helsinki. Digital impressions were taken with an intraoral optical scanner (CS3500, Carestream Dental, Atlanta, GA, USA). In the Case 1 prosthetic rehabilitations were realized on natural teeth. The prosthetic material used was monolithic zirconia, from 1.6 to 1.4 and from 2.7 to 2.4 frameworks were all performed in monolithic zirconia, while in the aesthetic area (2.3 to 1.3), technicians left on the structure a 0.8 mm vestibular space for ceramic layering. The internal fit was checked intra-orally, using a silicone based fit checking material (Fit Checker, GC, Tokyo, Japan). At this stage the accuracy of the bite relationship record was also verified. Monolithic zirconia frameworks were perfectly fitting both on teeth and on polyurethane model, then they were sent to dental technicians for ceramic layering of aesthetic area. During the final test, restorations were tried into the mouth to verify aesthetics, contact points and occlusion before cementation. The cement used was a resin cement (RelyX™ Ultimate, 3M Espe). In the Case 2, after removing squamous cell cancer of the third quadrant and after the lower jaw's remediation, patient was rehabilitated with a provisional total prostheses fixed on implants. Then all teeth of the upper maxilla were extracted after the radiation therapy. The patient was rehabilitated also with a provisional removable total superior prostheses. After 4 months six implants were inserted in the upper jaw to rehabilitate the patient with a bar screwed on implants. As in the first clinical case, a digital impression was taken initially with an intraoral optical scanner with healing abutments. Then the healing abutments were removed and the scan-abutments were screwed. Simultaneously on the digital impression's file, the areas with the healing abutments have been cut. The scan was re-performed merely in the areas with the scan-abutments. To evaluate the accuracy of the digital impression an aluminum bar was milled and a fixed provisional

prosthesis in PMMA was realized to perform the fit's check on the implant abutments before making the final prosthesis.

**Results:** CS 3500 CareStream® system has demonstrated an acceptable level of accuracy and precision for prosthetic rehabilitations on natural teeth and on implants. The combination of digital impression technology and the use of the monolithic zirconia had demonstrated the delivery of the final prosthetic device in a quick time without the need to remodel functional or aesthetic areas.

**Conclusion:** The digital work-flow combines intraoral optical impression techniques and CAD/CAM technology, in order to achieve a fully digital and successful way to deliver prosthetic restorations to patients, providing aesthetics and function in shorter intervals of time. In full arch impressions of multiple prepared teeth there are several difficulties such as the distortion of the material sometimes created by divergent teeth, humidity control, greater stress for the dentist and discomfort for the patient. The clinical outcome of this study was hopeful but a long-term evaluation is needed.

### A RCT on confounding factors affecting the marginal quality of intra-oral scanning

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**Aim:** To assess the clinical performance of different intraoral optical scanning (IOS) devices used in standardized conditions, evaluating the minimal distance required to produce a clear and well defined interproximal margin between a prepared abutment tooth and the soft tissue (vertical distance) and between the abutment and the adjacent tooth (horizontal distance) for partial restorations in posterior sites. The null hypothesis was that there is no difference in the performance of the different tested scanners.

**Methods:** Thirty patients with a mean age of 45 ( $\pm$  19.5) years (range 18-64) in need of an onlay / inlay in posterior sites were selected and randomly divided in three groups of ten (3x n=10) according to the used IOS for chair-side capturing: (A) GC-Europe (Aadva, Belgium); (B) True-Definition-TD (3M, USA); (C) Trios (3Shape, Denmark). All abutment tooth preparations followed the generally accepted recommendations

for CAD/CAM-restorations<sup>21</sup> with supragingivally located margins in order to remain directly visible. Clinical pictures were taken of each quadrant and the corresponding preparations. Afterwards, IOS was performed according to the manufacturers' instructions. Since the margins were all located supragingivally, no retraction cord or any other tissue retraction technique was used. A total of ten scans from each group (A), (B), and (C), were obtained and stored as STL-files. Each file was imported to the Exocad platform, into a laboratory scanner (Aadva, Tokyo, Japan). The software measured the distance between each margin and the adjacent tooth interproximally, and the gingival tissue. The distance at which the detection of the margin started to become unclear was recorded for both vertical and horizontal distances. Data was processed statistically by one-way ANOVA ( $p > 0.05$ ). This research was approved by the Ethical-Committee of the University of Siena.

**Results:** The number of scans rejected from the study due to obvious errors was 2 for D640, 3 for GC, 3 for TD; essentially, the first scanning shots made by the operator (20%, 30%, 30%). No statistically significant differences were found among the three groups. The minimum distance, from which a clear margin was visible was 0.5-0.6 mm for all images, regardless of which IOS was used.

**Conclusions:** None of the tested IOS in this study were capable of recording a clear and distortion-free digital impression when the cervical margin for a posterior partial crown was located at a distance of less than 0.5-0.6 mm from the gingiva or from the interproximal neighbor. Under the experimental clinical conditions, all IOS performed similarly.

### Orthodontic and orthopedic effects of surgically assisted rapid maxillary expansion: a digital analysis

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**Aim:** The purpose of this investigation was to evaluate orthodontic and orthopedic changes produced by surgically assisted rapid maxillary expansion (SARME) using a non-contact reverse engineering approach.

**Methods:** Dental casts from 9 patients (5 males and 4 females) with mean age 24.6-years old at the moment of surgery were obtained at baseline (T0) and at the end of treatment (T1). The casts were scanned by the intraoral scanner 3Shape TRIOS

3<sup>®</sup>. Then, linear measurements were performed on single casts at T0 and T1 by 3Shape Ortho Analyzer™ software. In particular, changes relative to intermolar width (IMW), intermolar width on gingival margin (IMWoGM), interpremolar width (IPMW), intercanine width (ICW), intercanine width on gingival margin (ICWoGM), palatal height and anterior arch length were assessed. Casts superimposition and alignment were obtained by using Geomagic Studio 10<sup>®</sup> software, and then the analysis of tipping was performed for the first premolars and first molars. An increase in the vestibular inclination (buccal tipping) from T0 to T1 was defined as positive (+), whereas a lingual inclination (lingual tipping) from T0 to T1 was defined as negative (-). Descriptive statistical analyses, including the mean and standard deviation, were calculated for all measurements. A Student's paired t-test was used to determine if there was any significant difference between means of linear pre- and post-expansion measurements.

**Results:** the results showed that from T0 to T1, the transverse changes were statistically significant, with an average increasing of  $5.30 \pm 1.95$ mm for

IMW,  $4.73 \pm 2.24$ mm for IMWoGM,  $5.46 \pm 2.87$ mm for IPMW,  $3.64 \pm 3.26$ mm for ICW and  $3.55 \pm 2.07$ mm for ICWoGM. The variations of palatal height and anterior arch length resulted not to be statistically significant ( $p=0.575$  and  $p=0.764$ , respectively). The tipping of first premolars showed an average  $0.43^\circ$  of lingual inclination with a large Standard Deviation ( $SD=8.77$ ) and first molars displayed an average of  $2.23^\circ$  of vestibular inclination ( $SD=8.77$ ).

**Conclusion:** increased transversal widths from T0 to T1 were observed. Very different values of tipping were found through the cases. Since the final models were acquired after fixed orthodontic treatment that followed the SARME, it is not possible to define whether the tipping values observed are attributable to the SARME procedure. The digital approach allows us to make accurate and repeatable measurements, a reliable superimposition of the digital models makes us able to perform an accurate comparative assessment between the pre- and post- SARME models. The results are encouraging, but they must be confirmed by further studies with larger sample and the presence of a control group.