Laboratorio Ortodontico

Accuracy Comparative Analysis of Dental 3D models:

3D Printing
DLP
Stereolithography
Milling

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Introduction

New 3D technologies have progressed fast in past years , to a point where the dental and orthodontic laboratories has rapidly adopted the transition between the traditional work at the workbench with Bunsen , micromotor , spatulas , and the digital dentistry and orthodontics .

Nowadays, however, the digital market trends have raises a significant query - whether the economic investment for the purchase of such new technologies, is adequate to the quality of the models fabricated.

Furthermore, a dental lab owner may find himself coming across companies and suppliers, which are sometimes far away from the dental industry, offering machines, services and (or) equipment, that promises miracles in terms of quality of the final product. For this reason, we had a strong objective to perform a professional study, which would allow carrying out and sharing a comparative analysis of models for sequential aligners' products while using and comparing different technologies.

Idea and design

The objective for this study was to be compared the same model, provided by different companies in terms of quality and accuracy. The selected model was a single STL file of orthodontic arch.

After a long study, a precise impression of the traditional type arch was selected. The arc was produced with the latest plaster materials. This specific arch was fabricated with plaster of class IV ADA , mechanically mixed under vacuum , according to the instructions provided by the manufacturer (photo 1). Then, the plaster model was cleaned from any form of imperfection and then was scanned it with a 3D scanner.

As soon as the high resolution STL scan file was obtained – it was sent to different companies whom were using different technologies, for the production of 3D models of these upper teeth.

The technologies used for this accuracy comparative analysis were:

- 4.1 Stereolithography SLA
- 4.2 DLP
- 4.3 3D Printing
- 4.4 Milling.

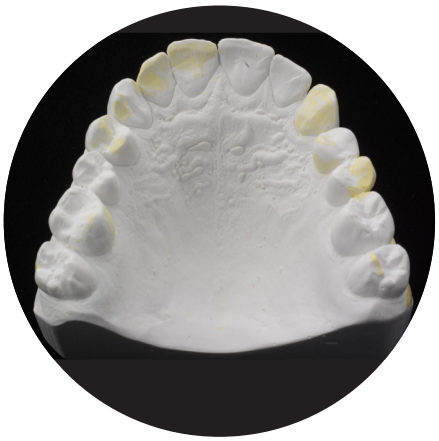


Photo 1

Visual analysis:

Upon receipt of the models produced (photo 2), we proceeded first to visual analyzes. Then, in order to realize their masks passive (photo 3) and wear them one at a time to test for look and feel impression.

During the visual inspection, we have immediately noticed that in some of the produced models, the teeth were quite different from the master cast in plaster. For example, some of them did not report a little place diastema between a lateral incisor and a canine (photo 4) . Even in the trial of the use of passive restraints printed, we have noticed that some in particular , tended to create a "draft".

As it was quite challenging to measure the accuracy differences in traditional manners – we have decided to scan every single produced model in order to perform a full accuracy comparative analysis.

The master template file was uploaded on a specific software capable of measuring in a very precise 3D files, and compared the model at a time, with perfect superimposed on it. In other words, we were comparing the traditional plaster scan model – with each scan model provided by each different company. The scan and compare took into consideration five points in different areas of the model in such a way as to always measure the same, for all the overlaps of the seven models 3D products.

In order to avoid any prejudicial and keep neutral approach, we have named the technologies with the letters A, B , C, D , E, F and G for not creating one-sided responses, while keeping professional approach. We have only named the best outcome results.

Photo 2

Photo 3

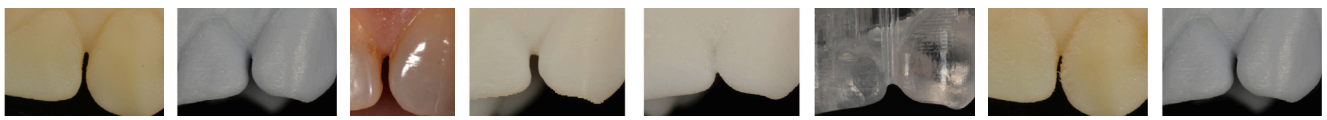


Photo 4

Measurements

During measurements, we have assigned a tolerance threshold of 0.020 mm (20 micron). Hence, in the table presented hereafter (photo 5) , the values recorded with the color green, are those that are between the value 0 and the value of 0.020 microns and all the outside this range, are marked with red color .

Machine A

Produced a model with technology MJP (Multijet printing) and the analysis of the values obtained in the five points taken into consideration , only one value is found to comply with the tolerance 20 micron provided then indicated by the color green in the table. The four values of red, all have a parameter after the comma, greater than 1.
For the reader convenience, we wanted to call errors for decreasing number from 0 to 4 , with reference to the number greater or less than 1 after the comma ; The table, however, includes the actual errors measured by scan-and-compare results.

Machine B

Created a model with technology (SLA Stereolithography technology) . In the analysis of the values obtained with this equipment , all parameters are beyond the tolerance limit , but only two values have a number greater than 1 and 2 The error produced by the machine "B" has a value of 2 then , more precise the previous year.

Machine C

Also uses a technology SLA but is produced by another company . Of the five values in red, then out of tolerance , two are worth more than 1 after the comma. Here too , therefore , the error is measured by the number 2 .

Machine D

Produced a model according to the DLP technology . This company manufactures projection curing machines at an affordable cost, Therefore, the use may not be particularly suitable for professional use in the dental industry . The values obtained, all red , almost three values greater than 1 after the comma. The error calculated it would point to the value of 2.5.

Machine E

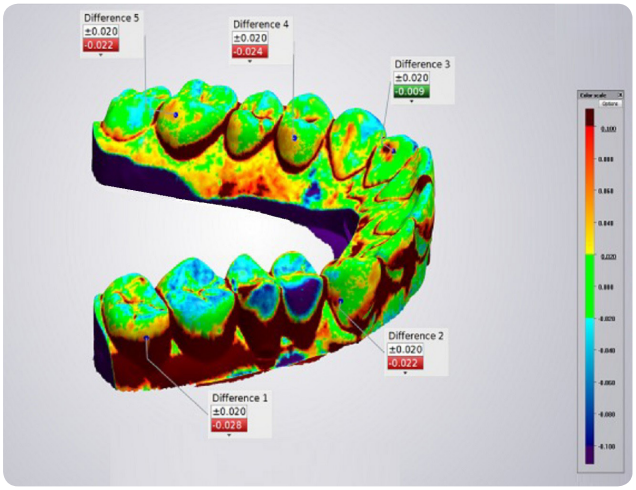
Uses a different type of technology in fact, it does not affix material to produce but takes it off : is a milling machine . The values obtained by this equipment during the production of our model, we have obtained two values , very close to 0 , therefore, one of them is colored green and three of the four values in red, have a number greater than 1 after the comma.

Machine F

Uses technology MJP (multijet printing) and required a 16-micron layers . In the 5 values obtained , one green was nearly equal to 0 while the other 4 , they obtained values with fewer than 0.5 after the decimal point , therefore, the cumulative error is indicated by 0.5 .

Machine G

is based on the 3D Printing technology (Eden260V Dental Advantage, by Stratasys). The results of this printed models has achieved the best score in scanning comparative results from all other systems compared, and therefore, to our opinion , this is definitely the most accurate model that obtain high satisfactory results for the dental and orthodontic market.



Machines	Type	Caption	Tol lower	Tol upper	Value	Deviation
A	Point difference	Difference 15	0,020	0,020	0,145	0,145
A	Point difference	Difference 14	0,020	0,020	-0,118	-0,118
A	Point difference	Difference 13	0,020	0,020	0,017	0,017
A	Point difference	Difference 12	0,020	0,020	-0,121	-0,121
A	Point difference	Difference 11	0,020	0,020	0,188	0,188
B	Point difference	Difference 5	0,020	0,020	-0,072	-0,072
B	Point difference	Difference 4	0,020	0,020	0,068	0,068
B	Point difference	Difference 3	0,020	0,020	0,078	0,078
B	Point difference	Difference 2	0,020	0,020	0,109	0,109
B	Point difference	Difference 1	0,020	0,020	0,222	0,222
C	Point difference	Difference 5	0,020	0,020	-0,155	-0,155
C	Point difference	Difference 4	0,020	0,020	-0,133	-0,133
C	Point difference	Difference 3	0,020	0,020	-0,063	-0,063
C	Point difference	Difference 2	0,020	0,020	-0,038	-0,038
C	Point difference	Difference 1	0,020	0,020	-0,043	-0,043
D	Point difference	Difference 15	0,020	0,020	-0,166	-0,166
D	Point difference	Difference 14	0,020	0,020	-0,186	-0,186
D	Point difference	Difference 13	0,020	0,020	-0,097	-0,097
D	Point difference	Difference 12	0,020	0,020	-0,054	-0,054
D	Point difference	Difference 11	0,020	0,020	-0,022	-0,022
E	Point difference	Difference 15	0,020	0,020	0,002	0,002
E	Point difference	Difference 14	0,020	0,020	-0,098	-0,098
E	Point difference	Difference 13	0,020	0,020	-0,368	-0,368
E	Point difference	Difference 12	0,020	0,020	-0,170	-0,170
E	Point difference	Difference 11	0,020	0,020	-0,169	-0,169
F	Point difference	Difference 5	0,020	0,020	-0,022	-0,022
F	Point difference	Difference 4	0,020	0,020	-0,024	-0,024
F	Point difference	Difference 3	0,020	0,020	-0,009	-0,009
F	Point difference	Difference 2	0,020	0,020	-0,022	-0,022
F	Point difference	Difference 1	0,020	0,020	-0,028	-0,028
G	Point difference	Difference 15	0,020	0,020	-0,010	-0,010
G	Point difference	Difference 14	0,020	0,020	-0,040	-0,040
G	Point difference	Difference 13	0,020	0,020	-0,029	-0,029
G	Point difference	Difference 12	0,020	0,020	-0,018	-0,018
G	Point difference	Difference 11	0,020	0,020	-0,004	-0,004

Photo 5

Conclusions

The clear conclusions of this professional study – are showing that the various technologies may carry significant margins of error in produced models. There was only one product, that achieved both the highest score for visual inspection, surface finish, and high accuracy – and that was the **Eden260V Dental Advantage, by Stratasys.**
We are confidence that any a dental or orthodontic lab, whom searching for adopting digital model fabrication – should not only assess a unit cost, or cost per case; but also other factors, as the ones evaluated in this report.

Odt. Fabio Fantozzi
Lavoro originale

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Laboratorio Ortodontico

Odt. Fabio Fantozzi

Fabio Fantozzi, Dental Technician, was born in Ascoli Piceno on March 17, 1970, and graduated from the I.P.S.I.A., San Benedetto del Tronto in 1990.

He totally dedicated himself to orthodontics, participating in numerous courses and meetings, throughout Italy and abroad, following the teachings of well-known professionals.

In 1991 he became an ordinary member of C.R.O.N.-O.M. (National Centre Orthodontic Research –Jaws Orthopaedists), then, in 1994, he was appointed member of the National Board of Directors. In the same year, after founding the Orthofan ™ Orthodontic Laboratory, of which he is the owner, he became a member of the GTO (National Association of Orthodontic Technicians) and then Territorial Head for the Marche, Abruzzo, and Molise regions.

At the end of the same year he participated in the international competition "Golden Pliers" organized by Ortec Club, ranking 5th in the "Golden Screw" award, with the display of a bi-maxillary functional appliance from the Dutch school: the Ducovator.

He is the author of over 40 technical articles, published in various journals of his field and in Internet, including some on sport mouthguards.

In May 1996 he was elected National Vice-President of GTO and Coordinator of the Regional Delegates for the three years '96, '97, '98.

Creator of T.O.M. systematic (Transbrackets Orthofan Method), I.P.A. (Indirect Positioning Arches) and E.C.S. (Etched Control System).

Speaker at numerous International Congresses CRON-OM: in São Paulo, Brazil, in 1996 and 2000, in Guayaquil, Ecuador, in 1997 and 2001, in Buenos Aires, Argentina, in 1998, in Rome in 1999 and 2007, in Marrakech and Casablanca, Morocco, in 2002, 2008 and 2013, in Isla de Margarita, Venezuela, in 2005, in Bucharest, Romania, in 2006, and in Dijon, France, in 2012.

Speaker at other conferences in Martinique, Antilles, in 2003; in France, at EEDP (European Exposition Dentaire Paris) in Paris, in 2004; at OTA (Orthodontic Technician Society), in Edinburgh, Scotland, in 2007; at GK, in Harz, Germany, in 2010.

In May 1997 at the XI Interregional Congress of the Dental Disciplines a work on "Transbrackets Orthofan Method" was presented by Prof. Sampalmieri, by Dr. Morgioni and Dr. Lamarca.

Speaker at various meetings, conventions and congresses throughout Italy and in many countries abroad.

Elected National President of GTO for the 1999-2001 period, he declined the appointment.

In 1998 he founded the "Orthofan Orthodontic Stages", of which he is Scientific Director and in which theoretical and practical courses for Dental Technicians and clinical courses are held by outstanding internationally known speakers.

In August 2001 he became member at large of ORTEC Club (Association of Italian Orthodontic Technicians).

He is authorized by Micerium S.p.A. to give courses on the customized lingual orthodontics system "Harmony" and on designing and manufacturing of the Distal Jet, following which the company enables the participants to purchase preformed kits.

Teacher of 'Orthodontic laboratory techniques' in the Specialty Program in Orthodontics at the 2nd level Master in orthodontic and gnathologic therapy at the University of L'Aquila in 2003.

Since 2009 he has been Adjunct Professor of Laboratory Methodologies II at the University of Trieste.

Since 2010 he has been the orthodontic technician speaker of ISO (Institute of Dental Studies), Leone S.p.A, Florence.

Since 2011 member of AIOT (Italian Academy Technical Orthodontics).

In 2013 he was appointed by the Brazilian inventor JR Ramos, exclusive official Certifier for laboratories across Europe for the fabrication of the OdontoApneia™ device.

Member of SIOS, since 2013, he held a video conference at the eighth National Congress, presenting the production of an individually customized mouthguard, with materials of the latest generation.

Registered in the list of Technical Consultants (CTU) of the Court of Teramo in the category of dental technicians.

Scientific director of the website www.ortodonzia.com.

Registered in the list of Experts Class XI, sub. No. 28 of the Chamber of Commerce of Teramo.

Author of the book "Orthodontic Technique", published by Edi Hermes in 2013.

He has lectured in orthodontic technique at the Universities of Messina, Siena, Trieste, Perugia and L'Aquila.

Orthodontic technician chosen for the stages of the 3rd area of IPSIA in San Benedetto del Tronto

He held theoretical and practical courses in several Italian cities and in the schools for Dental Technicians in Pescara, San Benedetto del Tronto (AP), and Matelica (MC).