Paradigm shift in alveolar model fabrication with 3D printing - Encompassing the Alveolar model workflow

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An optimal soft tissue profile on master models is essential for obtaining optimal aesthetics in anterior restorations. Fabricating quality anterior aesthetic restorations, such as veneers, crowns or implant-supported crowns, requires the fabrication of a master working model with soft tissue in hard material with removable dies. This model is essential to the integration of the definitive restoration with the architecture of the gingiva. (1) The so called “Alveolar model”, traditionally, has been manually fabricated in dental stone in labor-intensive procedures until 3D printing technology arrived to the market.

Figure 1, 3D printed Alveolar model with removable dies

3D printing is becoming a subject of great interest in dentistry. The technology has a particular resonance within dentistry with advances in 3 d imagining and object acquisition/modelling technologies such as intra oral scanning. With the relatively long history of the use of CAD CAM technologies in dentistry, it will become of increasing importance. Uses of 3D printing include the production of surgical templates for dental implant osteotomies and fixture placement, physical models for prosthodontists, orthodontists and dental technologists. It can be used to manufacture dental, craniofacial and orthopaedic implants as well as to fabricate copings and frameworks for implant and dental restorations and to fabricate models of all kind. Nevertheless, recent publications analyzing printed models observed that different commercially available 3D printers rendered a clinically acceptable level of accuracy based on the recorded dimensions of less than 100 µm different than the reference model. (2)
The aim of this paper is to review comparatively the differences between 3D printed alveolar models versus hand made stone cast alveolar models and the advantages that CAD_CAM technology can offer in terms of a dental model fabrication.

Analogue (hand made) versus subtractive (milling) versus additive (3 D printing).
The constant growth and increasing diversity of digital procedures to fabricate dental soft tissue models, leads to the question of, whether new technologies can potentially offer the same accuracy standards as the analogue existing techniques.
Any changes in a proven existing system have to be carefully considered and evaluated. Quality control must be assured as many commercially available systems are promising, but often they can not comparatively produce the same results as existing procedures.
3D printing has been hailed as a disruptive technology which will change manufacturing. Used in aerospace, defense, art and design, 3D printing is becoming a subject of great interest in surgery. The technology has a particular resonance within dentistry, with several advances in 3D imaging and modelling, milling and recently 3 D printing technologies (3)

Following the present article author's workflow protocol and in order to initiate a diagnostic template, an accurate set of functional diagnostic impressions with fully extended vestibular components must be made with the aid of a mono-phasic VPS material utilising a stock impression tray, in order to capture maximum accuracy in the reproduction of the control status situation. It is reference for anatomical wax ups, to fabricate silicone indexes for diagnostic mock ups, provisional restorations and tooth structure reduction guides. At this point many times the problem started, because the impressions did not fulfill the above mentioned requirements.
Furthermore, the inaccuracy will then be transferred, from the final impression of the preparations, to the definitive master cast. Due to missing information on the diagnostic impressions, the silicon matrixes for the diagnostic waxing transfer will not be positioned adequately on the master working cast.
The problem was resolved by generating an accurate scan and a printed study model followed by scanned preparations and a 3 D printed Alveolar model.

In this article the authors will depict 2 different cases with each multiple units from scan to final restoration. In both cases an analogue Alveolar model was fabricated as well as a 3D printed Alveolar model for direct comparison of accuracy.

CASE REPORT 1 in collaboration with Assist. Prof. Dr. Juan Mesquida Escalas and Dr. Ferran Llansana Fito

An 8 unit case in the maxillary arch with an osseointegrated implant on the left lateral incisor and multiple single units veneers and crowns from left first to right first premolar was presented. The scan body of the implant was placed in the right position and the fit verified radiographically.
Scanning processes were performed with the aid of an intra-oral scanner, Omnicam from Dentsply Sirona. An STL file was generated, exported and digitally sent to the printing center, Shera Material Technology GmbH in Lemförde, Germany.

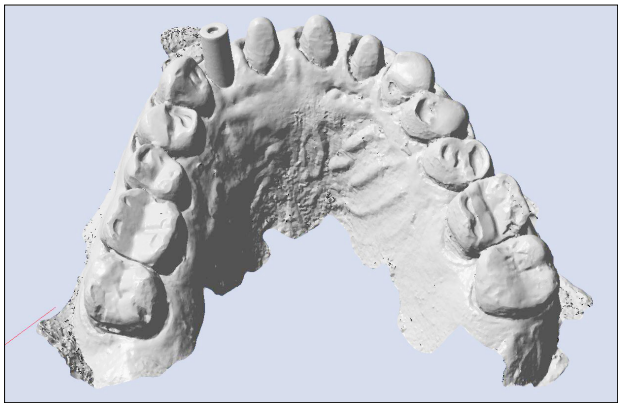


Figure 2, STL file of maxillary preparations and scan body for implant restoration

The 8 unit case was designed in the CAD model builder software and was sent to the 3 D printer which did the slicing calculation. The starting point for the process of the printing is a tank filled with a liquid resin, the so-called photopolymer. This resin reacts under the light influence and solidifies after a given exposure time. The DLP builds on this technical feature. A 3D model previously created by CAD is projected onto the surface of the liquid resin layer by layer using a projector. Thereafter, the solidified layer is pushed upwards by a mobile platform sequentially to the height of an additional layer. Liquid photopolymer collects again under the first layer, which is subsequently exposed again. Gradually, this creates a complete model. The unfinished model is then removed from the pool after printing has finished, put in a light chamber to be light cured to finalize the setting of the printed resin. Therefore, a complete an dimensionally stable model is produced. Once the process is finished, the printed model is cleaned with IPA alcohol, rinsed with water and placed in an ultrasonic bath unit for a recommended time no longer than 5 minutes. Afterwards, the model is air-dried, the support structure removed and the single, function- specific removable dies positioned . (5)

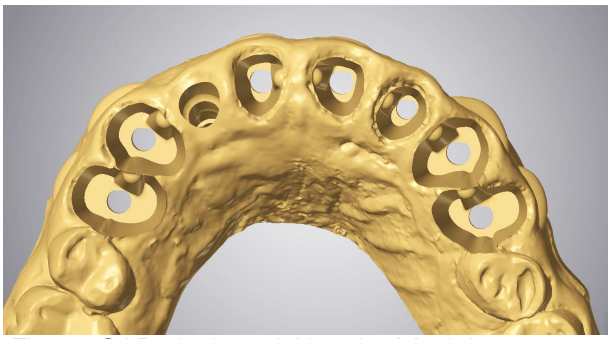
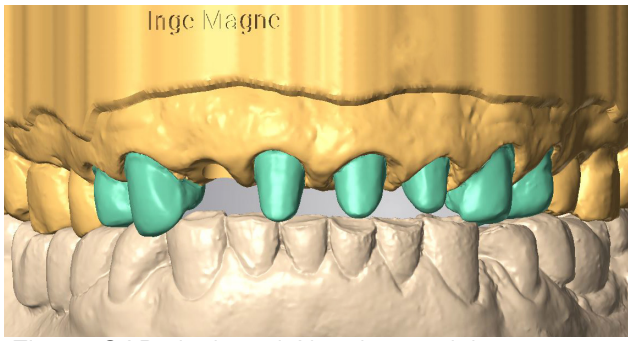


Fig. 4, CAD designed Alveolar Model



Flg. 5, CAD designed Alveolar model with removable dies in occlusion

Figure 3, Shera printing Unit

Figure 6, 3 D printed Alveolar model with removable dies for multi unit restorations

Figure 7, # 5, 6 ,11, 12 veneers, # 8 implant supported zr crown, # 9,10,11 zr crowns on Alveolar model

Figure 8, situation with abutment # 7

Figure 9, # 5, 6 ,11, 12 veneers, # 8 implant supported zr crown, # 9,10,11 zr crowns in situ

Figure 10 + 11, due to the accurate printed Alveolar model, the marginal adaptation in situ is given

CASE REPORT 2 in collaboration with Dr. Violeta Bartalis ép. Claus

An 11-unit single crown case in the maxillary arch with was presented. With the aid of an intra-oral scanner, Trios3 Color by 3shape , an STL file was generated, exported and sent to the printing center, Shera Material Technology GmbH in Lemförde, Germany.

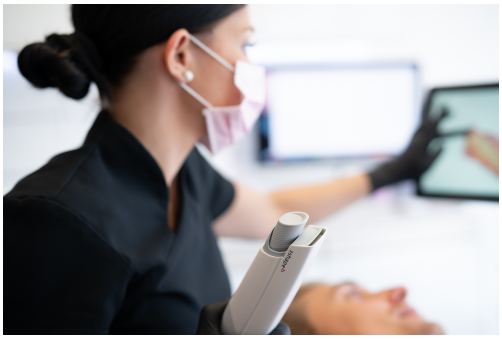


Fig 12, intra-oral scanner, wireless Trios3 by 3shape

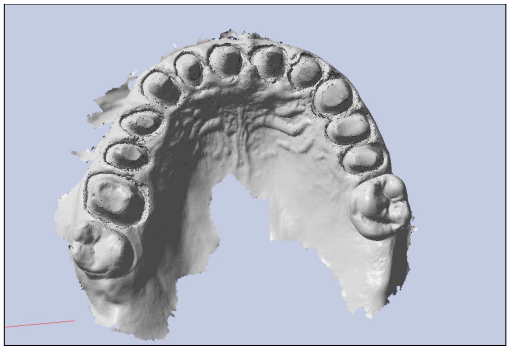
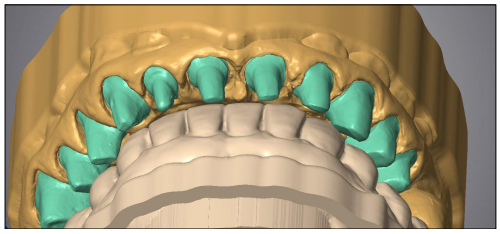


Fig 13, STL file of 11 maxillary preparations



Flg. 14, CAD designed Alveolar model with removable dies in occlusion

Flg. 15, scan of wax up in occlusion

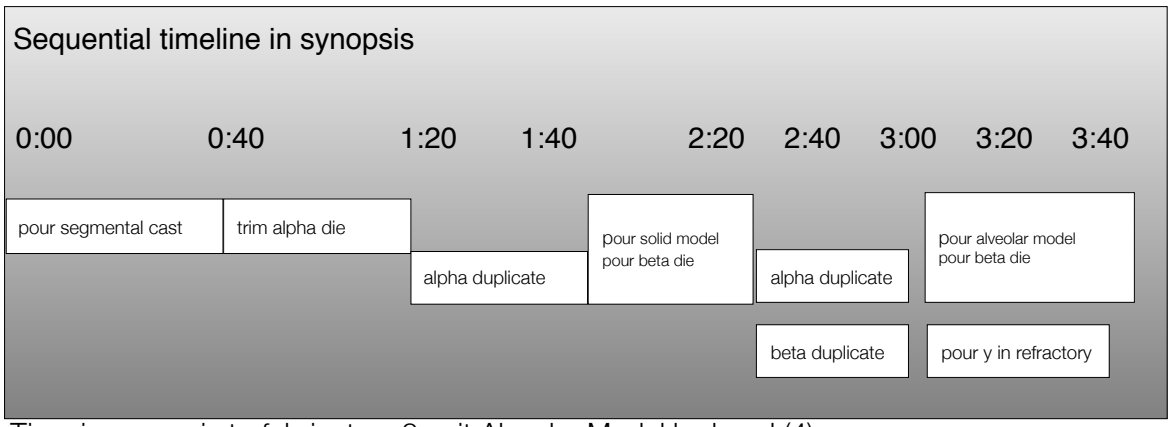
Fig, 16, 3 D printed Alveolar model

Fig. 17, 3 D printed Alveolar model with 11 EMAX crown in bleach color

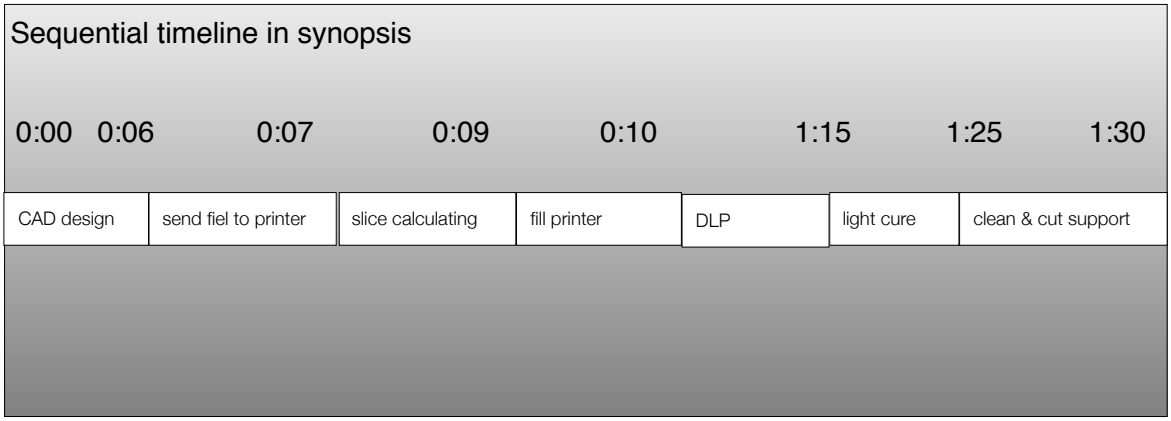
Patients' wish to receive an ultra bleached " Hollywood smile" was respected. A 3D printed prototype of acrylic provisionals was tried in situ and functional, esthetic and biologic requirements evaluated. After acceptance of shape and color, the final restorations were fabricated and cemented. The protocol and workflow was developed in the same manner as case 1, being the differential factor the intra oral scanner utilized.

Fig 18 + 19, 11 EMAX crowns in situ

Figure 20, 11 EMAX crowns in situ - happy patient



Time in synopsis to fabricate a 8 unit Alveolar Model by hand (4)



Time in synopsis to fabricate a 8 unit Alveolar Model in 3D CAD design and Print

As shown in the 2 graphics above, the entire working time for an 8-11 unit case takes for the CAD design approximately 10 minutes, the actual printing process is 1 hour and 5 minutes, Therefore, the effective working time of a technician is approximately 10 minutes.
Compared to the the analog workflow labor time and the holding / setting times of stones and silicones, which must be always under observation during the model making process, the effective work time is approximately 3:40 hours. Hence, the advantages of the printed Alveolar models are clearly visible in the above depicted synopsis. Nevertheless, the overall advantages /disadvantages remain a field for improvement and discussion.

Advantages of the 3D printed Alveolar model::
- Decreased production time
- Ease of patient data sharing and processing
- Highly detailed and accurate models
- Material stability
- No loss of information during working time
- Ease of replicability if an additional model or die is required
- Educational upgrading, models for teaching purposes can be reproduced at low cost
- Additive model production needs about 40 % less material than subtractive (8)
- Outsourcing possible

Disadvantages of the 3D printed Alveolar model:
- Photopolymers are currently expensive.
- Financial expenses related to hardware (3d printer, intraoral scanner) and design software.
- Maintenance costs

In conclusión, given the 18 year author's experience in the fabrication of the Alveolar Model and a careful analysis and refinement of the technique in terms of accuracy and time-effectiveness, an objective comparison of both the conventional fabrication and the modern digital approach of a Alveolar model was necessary in order to warrant a predictable transition into the latter. The aim of this paper is to clinically report two clinical scenarios where printed models rendered a comparable level of accuracy to stone models and to emphasize on the time efficiency observed of the digital systems utilized hereby.

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