Supplement: Model Fabrication Manual (by Anas Al-Jadaa)

Assessment of Irrigant Agitation Devices in Simulated Closed and Open Root Canal Systems[1]

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The model fabrication followed a multiple stage casting method. In principle, a reference model of acrylic was fabricated by which duplication of the model with epoxy resin was conducted to produce the experimental models. The following figures explains step by step the model fabrication process. The implementation of model in the test set-up is explained in the publication.

1. Fabrication of the Reference Model

The canal anatomy represented two prepared canals to size Large Wave One Gold (Figure 1, A). A straight and a curved canals were simulated with the corresponding gutta-percha points to the desired size. The curved canal formed a 45° angle with the straight counterpart. The straight canal length was set to 14 mm while the curved canal was set to 13 mm. The simulated isthmus space was modeled using a double layered metal matrix band (Tasma Metalova Metal Tape Stainless Steel, AnGer G&A, Szczyglice, Poland) to a total thickness of 0.09 mm. Its width was 4.5 mm coronally and 0 mm apically. The parts were glued together with Super Glue 101 (Scotch Brand, 3M, Saint Paul, MN). The Pulp chamber was simulated with a rubber heavy body impression material (Hydrorise Maxi heavy viscosity A Silicone, Zhermack, Badia Polesine, Italy). It was 3 mm in depth, 6.5 mm in width and 7.5 mm in height. The simulated root canal system was then cast in an acrylic two-piece reference model (Vertex Dental, Soesterberg, The Netherlands). One side of the model was cast with the acrylic material to halfway the Gutta Percha thickness (Figure 1, B and C). In the open system model, a periapical lesion was simulated. The latter was milled in its reference model to a length of 15 mm, a width of 8 mm and a depth of 0.75 mm with a precision milling machine (Figure 1, C).

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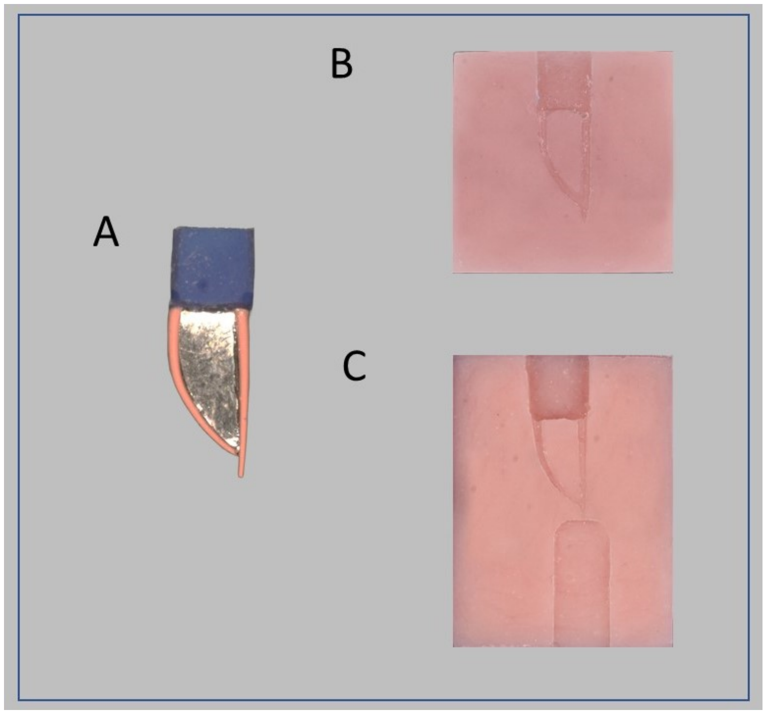
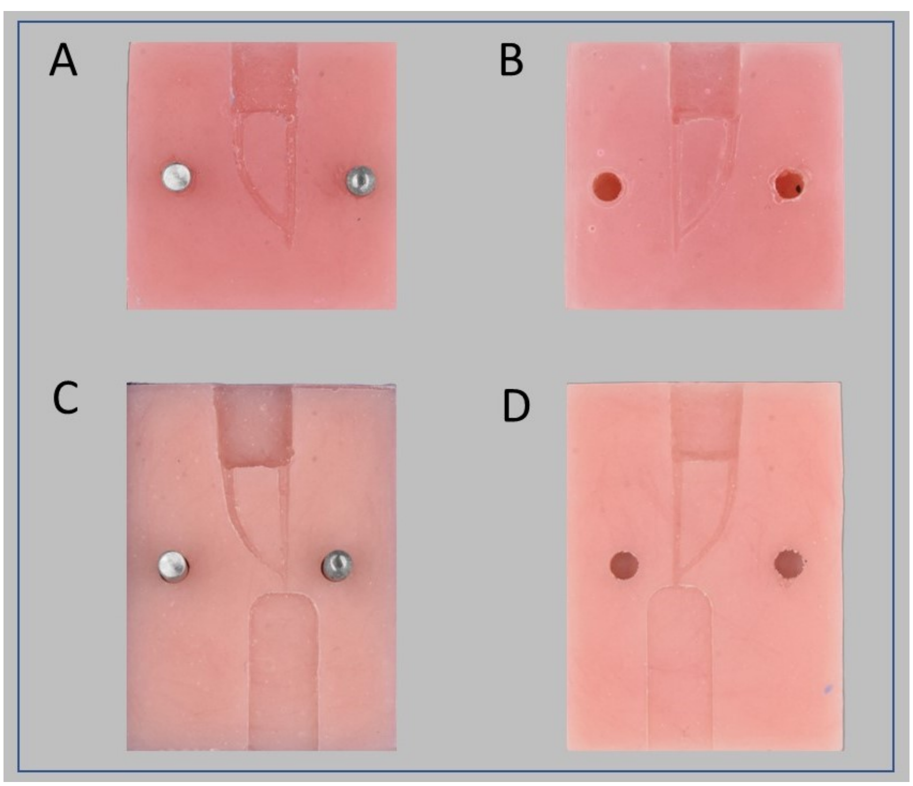
[1] Supplement on Model Fabrication

Figure 1:



The first cast model half for both model's types was drilled on both right and left to the anatomy to create index holes of 3 mm diameter. Index pins were fixed in position (Figure 2, A and C), the interface was isolated with Vaseline, the simulated canal anatomy repositioned, and the model counterpart was cast with acrylic (Figure 2, B and D).

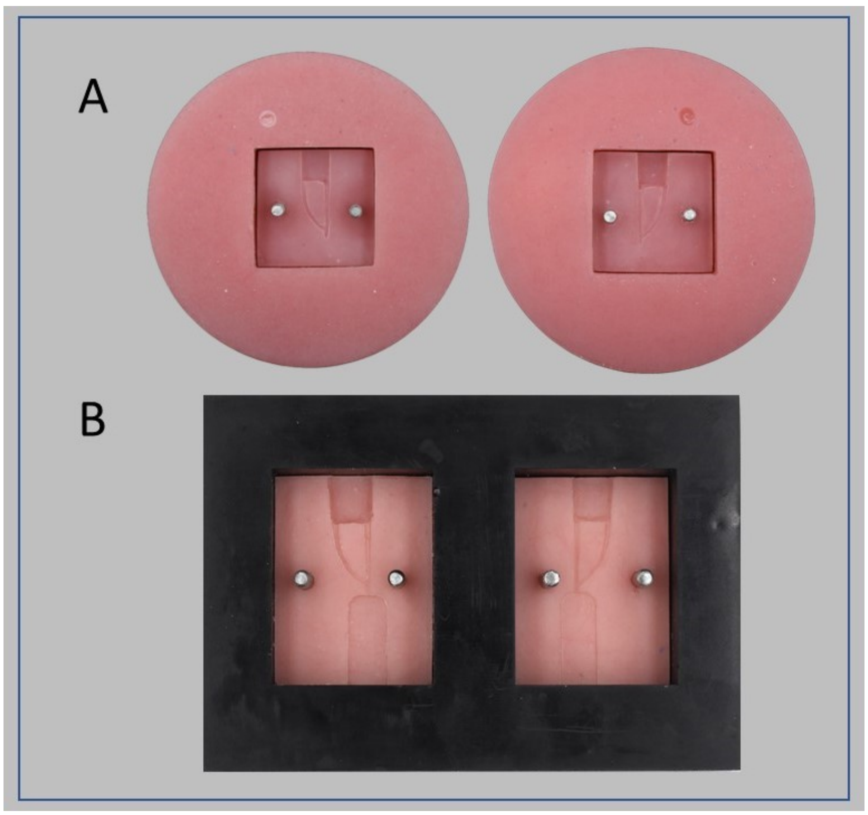
Figure 2:



After separation of the two-part models, a counter simulation of the apical lesion in the open system model was milled as previously described (Figure 2, D).

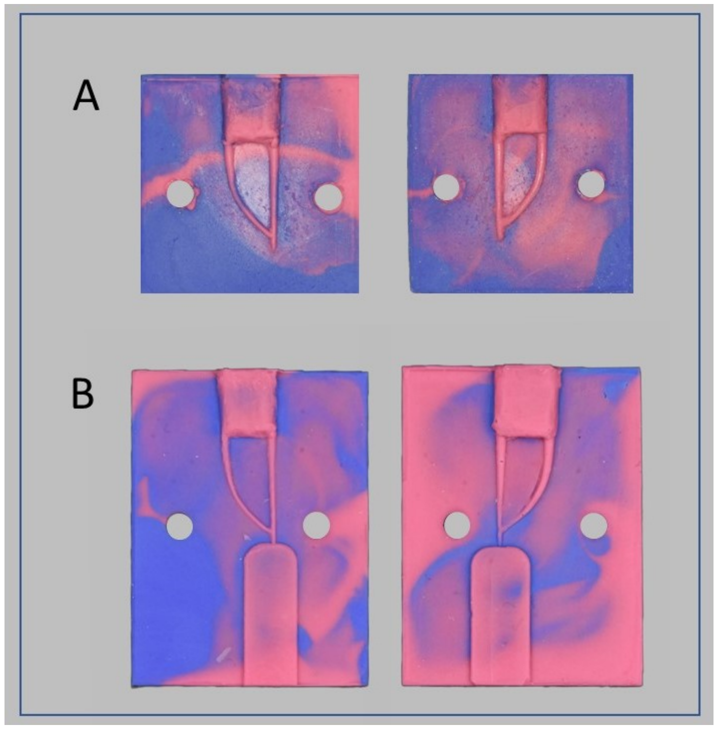
Index pins were fixed to all parts and casting frames were created to facilitate the copying process (Figure 3). In the closed system, the frames were created with cast acrylic material (Figure 3, A). At a later stage, 3D printing was used create the frames for the open system reference model as it is more convenient (Figure 3, B).

Figure 3:



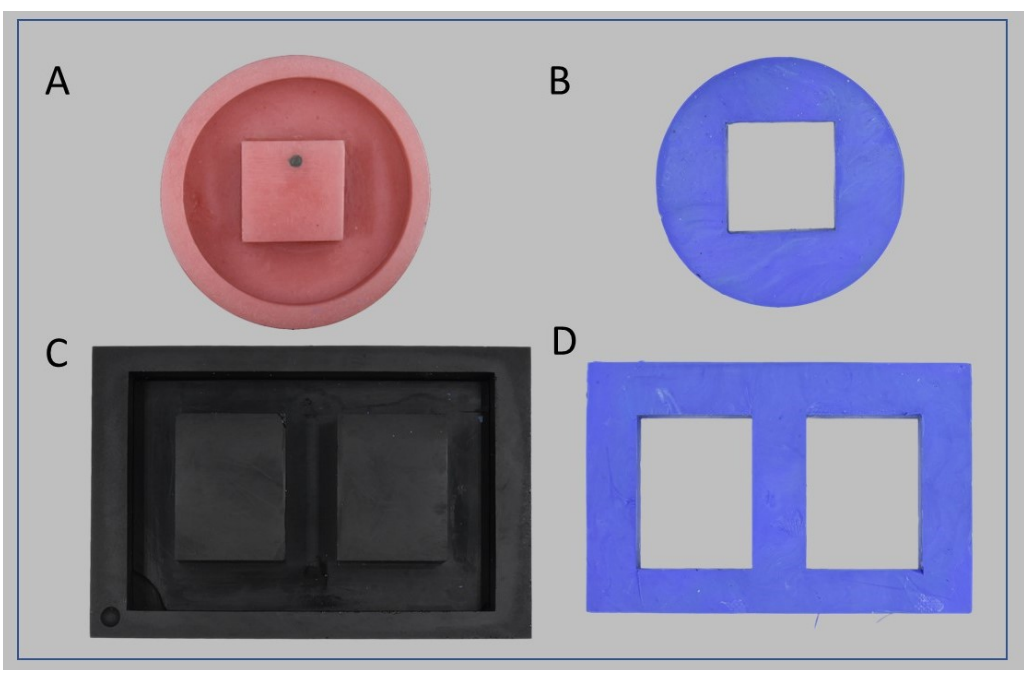
Positive copy molds were then created with a single step impression technique (Hydrorise, Zhermack; Figure 4, A and B).

Figure 4:



To create molding frames for the test models, acrylic and 3D printed molds were implemented (Figure 5, A and C). They allowed creation of rubber frames in which the rubber positive molds created in the previous step (Figure 5, B and D). This was aimed to ease the removal of the final cast epoxy test models. Simultaneously, this setup allowed the reuse of the molds without any effect on their dimensions.

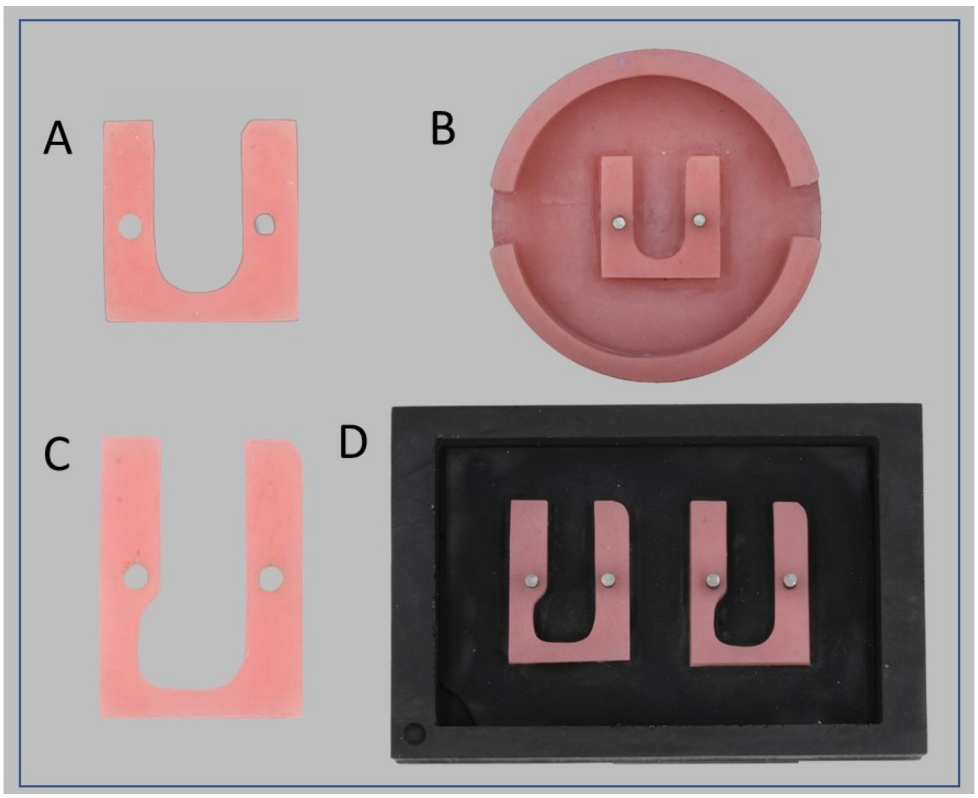
Figure 5:



2. Fabrication of the Supporting Skeleton

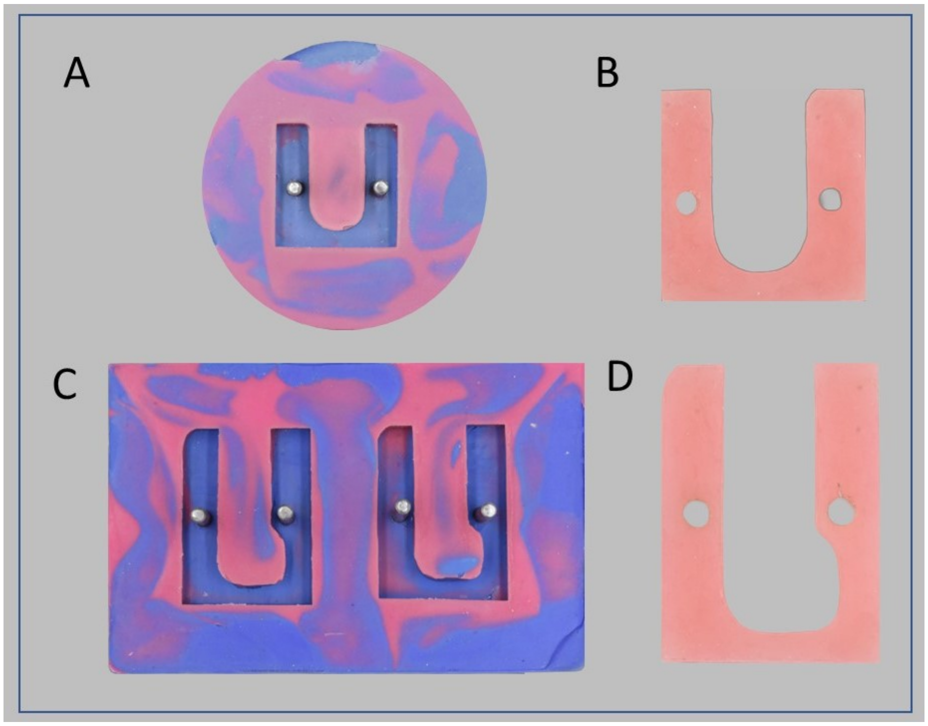
The epoxy material was somewhat fragile. When tightening two pieces with screws as in our case, cracks and fractures were noticed. To overcome this problem, an acrylic skeleton was embedded in the epoxy test models. A similar molding technique as previously described was used. An acrylic cast of the model, 5 mm thick was produced for each model type. The cast acrylic part was down-trimmed on the sides and in the middle in a U-shaped form (Figure 6, A and C). This step was important to avoid obstruction of the epoxy test models to be produced. Simultaneously, it allowed transfer of the exact hole in the model. Index pins were fixed to the holes and the work pieces were fixed to acrylic and 3D-printed molding frames to ease the impression process (Figure 6, B and C)

Figure 6:



Single-step Rubber impressions of the skeleton were made (Hydrorise Maxi heavy viscosity A Silicone, Zhermack), see Figure 7, A and C. Fitting index pins were positioned in the holes of molds and the acrylic skeletons were cast (Figure 7, B and D).

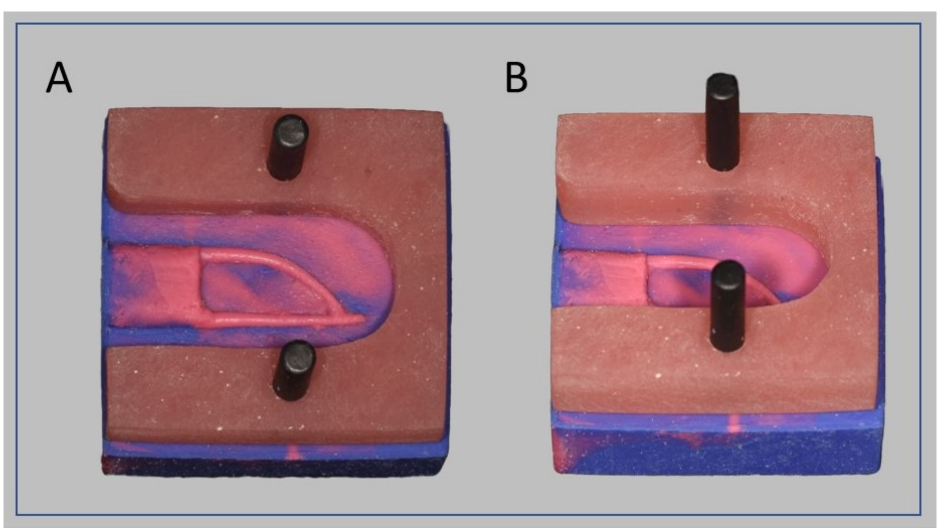
Figure 7:



3. Casting of the Epoxy Test Models

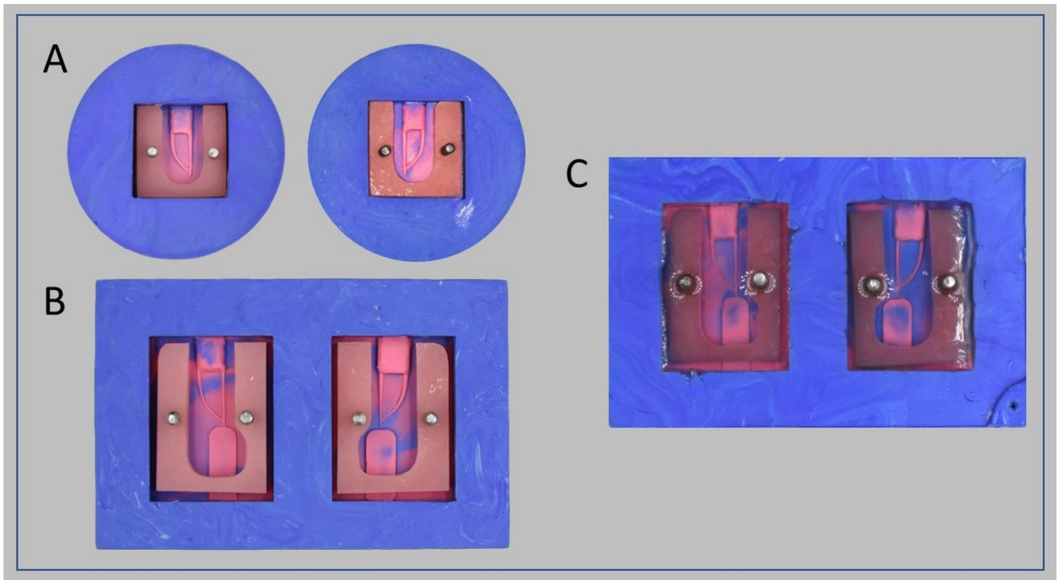
The test model casting was the last step and was based on collecting the previously produced parts together in one piece. The index pins were repositioned in the acrylic skeleton according to the model type, the set up was positioned in the positive model rubber impression (Figure 8, A). A space of 1 mm between the acrylic skeleton and the rubber positive mold was left to allow the flow of epoxy material and result in a better adaptation in the final model (Figure 8, B)

Figure 8:



The set up was transferred and positioned in the rubber frames of the corresponding model type (Figure 9, A and B). Subsequently, the mold was cast with Epoxy resin (Art Epoxy Resin, EPOKE, Bengaluru, India). (Figure 9, C)

Figure 9:



The epoxy was left for 24 hours to set. The model was removed from the mold, and index pins were dissembled to get the final epoxy test models (Figure 10, A and B).

Figure 10: