

Orthodontic Records:

Collection and Management Guidelines for 3D rendered orthodontic digital study models

Reviewed 2022



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What are 3D rendered orthodontic study models?

Currently plaster study models are produced as an intrinsic part of the care and management of an orthodontic patient. Although considered essential for planning and monitoring orthodontic care, storage and long-term retrieval can be problematic. 3D digitally rendered orthodontic study models offer significant advantages over plaster models in terms of both storage and retrieval.

Advances in digital imaging have resulted in 3D orthodontic study models being at the forefront of any modern and contemporary orthodontic practice. The images can be obtained either directly using intra-oral scanners or indirectly by scanning dental plaster models or impressions. Although the popularity and market penetration of intra-oral scanners is currently low in the UK (probably due to cost), these technologies are likely to become more prevalent in everyday dental practice in the coming years.

Current evidence has shown that 3D orthodontic study models can replicate conventional orthodontic study models in terms of planning, monitoring and evaluating treatment. However, it is important to ensure that the quality of the scanned data is sufficient to enable physical replicas to be reproduced (using 3D printing or milling). This will help in medico-legal cases, particularly during the few years where clinicians are generally used to the tactile feel of a set of dental study models.

To achieve a desirable set of guidelines for the use of digital models, three areas need to be addressed:

1. That 3D scans are at the appropriate level of quality required to reproduce an accurate 3D printed model.
2. To ensure that 3D models are occluded accurately in the intercuspal position.
3. Consideration should be given to the current retention periods of 3D orthodontic study models, and specification relating to the security and permanency of this data with appropriate audit trails.

If these criteria are fulfilled, 3D orthodontic study models can be used not only in the management of orthodontic patients, but also to provide valid long term storage of orthodontic patient records.

1. A recommendation of a minimum quality/data capture of a 3D scan required to reproduce an accurate printed 3D model from the original captured image

Currently, accurate and reproducible 3D printing can create dental study models providing the same clinically valid information as plaster models. There is also some evidence to suggest 3D printed models can replicate orthodontic scores to a clinically acceptable level within an arch.

One of the major benefits of 3D printing would be to allow clinicians to manually occlude models and feel for the ICP position. To achieve this, the 3D printed models should be as similar to the original plaster models as is reasonably achievable.

A suitable 3D image requires a vertex density (number of recorded data points) sufficient to ensure minimal visible faceting on the printed model, and minimal error compared to a full resolution scan. For example, STL images are typically made from triangles. By colouring the triangle in a graded way, the image on screen appears smoother than it would when 3D printed. This means what may be acceptable to the eye on a computer screen, may not be acceptable to the eye on a printed model.

In practice, the following is suggested as a minimum data standard, if the models are likely to be required to be 3D printed in the future:

~200,000 vertices (400,000 triangles), creating a reasonable quality model (max error <100 microns, max triangle edge length 0.6mm).

It should be noted that the 'maximum edge length' restriction should only be applicable to clinically relevant areas (the dentition and surrounding tissues). It is not applicable, for example, to the base of the printed model.

Also, for 3D printing, the models must have no 'non manifold edges' and no 'non manifold vertices'. The maximum allowable slice thickness for printed models should be 50 microns (desirable 30 microns). This limits the amount of 'layering' visible to the eye. X-Y print resolution should be similar to slice thickness.

In summary the requirements for producing accurate and reproducible 3D printed models, suitable for orthodontic purposes, should be:

200,000 vertices (typically 400,000 triangles), where the maximum difference between this and the original model is less than 100 microns, and the maximum edge length of a triangle is 0.6 mm, in areas of clinical importance.

Printed with a maximum slice thickness of 50 microns and a similar X-Y resolution.

2. Reproducibility and accuracy of the occlusal registration

The quality of the occlusion is arguably more important than the quality of the individual scan of the dentition. This is because many aspects of orthodontic indexing relate the upper and lower dentition (e.g. overjet, overbite, centerlines, buccal/canine occlusion). It is therefore vital to ensure 3D scanned models are accurately related to each other.

The occlusion should be correctly articulated to less than, or equal to, 0.25 mm in any direction with the desirable quality being less than 0.25 mm error.

A quality assurance programme should also be implemented (a simple, documented, 'human' check should suffice) as a means of verification prior to either the acceptance of the 3D image and the disposal of the indirect record (i.e. the dental impression or stone models). For quality assurance, the incorporation of the existing patient clinical data is essential. This would be a minimum of one or two pieces of clinical data, however ideally both.

- Confirming the clinical examination of the occlusal relations recorded by the clinician in three planes of space such as: overjet, molar relationships, canine relationships, centerline relationships, overbite relationship, crossbite relationships, so that the 3D models are correct to the articulated scanned models.
- Confirming visually that articulated scanned models corroborate the accurate clinical photographs of the patient in occlusion.
- An auditable quality assurance trail is fundamental in the validity of the scanned 3D models being an accurate record of the patient's occlusion, prior to the destruction of the indirect patient's record.

3. Consideration of current retention periods with 3D orthodontic study models and appropriate audit trails relating to security of this data

As stated in the BOS guidance, "Orthodontic Records, Collection and Management", a complaint or claim for clinical negligence is more likely if treatment has been less than satisfactory, especially if it involved an adverse incident or complication. Ideally Orthodontic Records which might involve any patient dissatisfaction or for particularly complex cases should be kept indefinitely. It is not possible to know when a case may become litigious. Currently, technology exists to store digital dental models securely, reliably and indefinitely.

This technology would be an adjunct to the current guidelines as stated in the BOS guidelines, "Orthodontic Records, Collection and Management". As with all computerised records, it is important that digital images are securely stored and access to the images is subject to an audit trail to ensure that no allegations could be made that the images have been manipulated in any way.

The majority of orthodontic and dental practices use either "in-house", or bespoke secure server companies to store their data. As data storage becomes cheaper, it would not seem unreasonable to consider extending the period of retention of 3D study models from the current guidance. This is at the discretion of the orthodontist, however the Law of Tort states that the plaintive has 11 years since knowledge of the case of harm or wrong doing, and so it would be prudent to err on the retention of records for as long as possible, as outlined by the Dental Protection Society:

"Dental Protection's advice would be to adopt the period of time set out under the NHS Code for Community Care as an absolute minimum and to retain records for as long as possible. Dental Protection advises that records that relate to complex treatment or particularly difficult patients should be kept for longer, up to 30 years." With specific reference to 3D study models, the Dental Protection Society states "It is sensible to store records by scanning them and then destroying the originals but the 30 year maximum storage period applies in any event."

In summary

The evidence shows that 3D orthodontic study models can replace conventional orthodontic study models, as long as the scans are at the appropriate level required to reproduce an accurate 3D printed model. This would only be valid if the 3D models are articulated accurately and are an accurate record for long-term retention of orthodontic records.

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**Updated by the Clinical Governance Directorate
of the British Orthodontic Society 2022.**

Recommendations may change in the light of new evidence.

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