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PRACTICE AIDS

The Use of Laser Holograms in Study Model Storage

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Introduction

In a large orthodontic practice or hospital department, the storage and recall of study models presents a major problem in both space and time and therefore cost. Keating et al. (1984) give the example of the Eastman Dental Hospital, London, where up to 200 model boxes are recalled and returned to storage during a day's work, involving several members of staff. *With medico-legal requirements that study models are retained for seven years* after completion of treatment further exacerbating the problem, any way in which this could be reduced would seem to have obvious benefits.

Keating and his co-workers (1984) therefore suggested that the use of holographic film to record three dimensional images of study models would meet the needs of this problem. The purpose of this communication is to present a preliminary report on the technique and its application and advantages in clinical use in the hope that a wide interest will be stimulated within the orthodontic profession in Australia. It is intended that a pilot study will commence very soon in Perth in conjunction with a Perth company * specialising in holographic and laser sales and consultancy which already has the capacity to produce up to 2000 holograms a week.

Technique

The wavefront reconstruction process, or holography, was first discussed by Gabor in Nature (1948), but the development of the laser beam in the sixties revolutionised this process and enabled its application in many scientific fields to be greatly enhanced. It is not the purpose of this article to describe in detail the physics of holography but a brief description of the technique employed in the preparation of study model holograms will be given.

The actual study model to be copied is placed on a large stability table on which is housed the laser and associated optics. Absolute stability is essential to prevent any external vibration, as a movement of even half a wavelength will affect the quality or even destroy the image. The type of hologram used is a single beam reflection, or Denisyuk hologram, in which the beam passes through the film first as the reference beam and is reflected back onto the film as the diffracted object beam, both beams being co-axial.

The study model is therefore placed at the correct viewing angle on the *stability table*, the laser is aimed at the model and the beam spread by means of a lens system. This bathes the model in laser light enabling correct exposure levels to be made. The beam is then blocked, film loaded in front of the model and the system allowed to settle for five minutes to eliminate all vibration. The exposure of about two seconds then takes place and the film is processed almost immediately using a three stage development/bleaching process in a conventional darkroom. After drying, the hologram is viewed at the same reference angle used in creating it by means of a pinpoint white light source, which eliminates the need to use the original laser beam for reconstructing the image, as in a transmission hologram, thereby producing a *great saving in cost*.

*Laser Arts

Method

Keating et al. (1984) carried out an investigation into the accuracy of the virtual image produced by this method. A study model and the hologram of that model were measured using vernier calipers accurate to 0.02mm. and twelve different dimensions representing most normal requirements were recorded ten times each on the model and the hologram. The model was measured directly and the holographic image was measured using the calipers on the image. Half the measurements were made at one time and the other half one month later.

Discussion

The results showed that the hologram was clinically useful - random errors for both model and hologram were clinically insignificant being only slightly greater than 0.33mm. at maximum.

Recent development of the reflex metrograph, which can be used to *measure objects three-dimensionally,* without physical contact, by means of digitization for computerised data, has improved the accuracy of both study model and intraoral measurements (Takada, Lowe and Decou (1983) and Butcher and Stephens (1981).This instrument is now being adapted for use with holograms.

Conclusions

Apart from study models, no method other than holography produces accurate three-dimensional records of the teeth and, from a clinical point of view, it is possible to record five views on one holographic film i.e. mandibular and maxillary occlusal, frontal in occlusion and left and right three quarter views in occlusion.

The *advantages of this method* can therefore be summarised as follows.

1. The films are relatively indestructible and can be scratched or bent without damage.
2. The space-saving characteristic is self evident. Once study models are no longer required clinically they may be transferred to holographic form.
3. Holograms may be easily mailed using a standard envelope.
4. Detail down to 1 micron can be captured due to the unparallelled power of resolution of the laser beam.
5. Superimposition of one hologram on another can be performed enabling tooth movement to be accurately detected.
6. Encoding of patients' data on the hologram (name, date, age etc.) is possible, making loss much more unlikely.
7. Holograms of this type can be copied easily if required.
8. More than one image can be stored on a single film.
9. The virtual image can be measured very accurately in three dimensions.
10. Reconstruction of the image for clinical purposes is easy using a white light source.
11. The cost of the process is very similar to that of conventional photography and could be reduced significantly if large quantities were to be produced.

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RESEARCH AIDS

Caution in the extrapolation of biomechanical concepts

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In a very significant contribution to the literature (Burstone and Pryputniewicz, 1980) dealing with the movement of teeth as a consequence of orthodontic forces, the concept of a centre of resistance was addressed. It was stated that 'By definition, the centre of resistance is found at the point where a single force produces pure translation' An experimentally determined centre of resistance of a ten times model of an upper central incisor was described. This was shown to have close coincidence to the theoretical centroid of a simple two dimensional parabolic model of a tooth and even closer coincidence with the theoretical centroid of a paraboloid of revolution. The theoretical treatment, like the experimental model and its data, is impeccable in this work and lends support to those who derive comfort from the concept which puts the centre of resistance at the centroid of the tooth root.

Notwithstanding an acceptance of the limitation of the physical model in attempting to simulate the biological environment in which the force system is operating, there is at least to my mind a residual concern about the basic concept of a 'centre' of resistance, particularly when extrapolated to more *complex situations*. If the definition referred to above implies that regardless of the direction of the applied force vector, only translation will occur then it may well be true that only one 'point' in the root of the tooth will be found through which all the resultant vectors of resistance will pass in response to an applied force vector.

However, if we examine the vectors operating in response to a simple system with an applied load it may become apparent that such an applied *load will be resisted by a variety of forces*, the vectorial nature of which will depend on the applied vector and the supportive environment of the root. This leads then to the notion of a resultant vector of resistance. It needs to be appreciated that only in those special circumstances where the root morphology approximates a three dimensional form with an axis of symmetry along the long axis of the root will the location of a point through which all of the possible resultant vectors pass be so readily identified as it is with a paraboloid form.

The extrapolation of the concept of a centre of resistance to the identification of such a centre in relation to a complete dentition must be at best speculative. This is so a fortiori with regard to a maxillary bone with its complex articulations.

Expressing this view is not to denigrate the reporting of accurate clinical observations. Rather it is a plea for recognition of the limitations that must accompany many of the assumptions necessarily made in the study of biomechanics so that data obtained based on those assumptions are not used indiscriminately to rationalise conclusions derived from clinical observation for which there may well be other equally acceptable explanations.

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