Holographic Methods for the Evaluations of Gingival Margins Retractions

MARIUS MANOLE[1], COSMIN SINESCU[2*], CIPRIAN DUGHIR[3], ALDO DE SABATA[3], MEDA-LAVINIA NEGRUTIU[2], CRISTINA BRATU[2], LAVINIA ARDELEAN[2], LAURA-CRISTINA RUSU[2], STEFAN STRATUL[2], MIHAI ROMINU[2], DIANA DUDEA[1]

[1]University of Medicine and Pharmacy Iuliu Hatieganu from Cluj Napoca, Faculty of Dentistry, 8 Victor Babes Str., 400023, Cluj-Napoca, Romania

[2]University of Medicine and Pharmacy Victor Babes from Timisoara, Faculty of Dentistry, 9 Revolutiei Blv., 300070, Timisoara, Romania

[3]University of Politechnica from Timisoara, 2 Pta. Victoriei, 300006, Timisoara, Romania

The retraction of the gingival margins was evaluated by holographic methods using a He Ne laser with 1mV. The impressions of the maxillary dental arch were taken from the patient in the first visit and then after six month. The hologram of the first model was superposed on the model cast of the second model. The retractions of the gingival margins could be evaluated three-dimensional on every point of interest.

Keywords: holograms, gingival margins, laser beam

Holography offers new nondestructive possibilities for bridging the gap between in vitro and in vivo measurements in dentistry, and thus increases the possibility of achieving more accurate and sometimes more objective diagnosis and therapy. The use of stone and plaster study models is an integral part of any dental practice and is required for research. Storage of study models is problematic in terms of space and cost. Various methods have been employed in the threedimensional (3D) assessment and recording of dental study models. These include Holography and Moire Topography. Holography was introduced in 1948. However, it was the work of Leith & Upatnieks that revolutionized holography with the application of the laser beam. Holography allows direct measurement of 3D displacements of a few micrometres. The major problem with this technique is the poor quality of recording the details of the study models, particularly in the incisor region. An advantage of holography is that films may be stored with medical records and it is a further step towards achiving dental study models. However, it cannot totally replace the original models [1- 4].

A new accurate method for comparing tooth positions on dental casts at different stages is described by Hans Rydén. Holograms of casts were prepared with a helium-neon gas laser. For evaluation of tooth movements, a cast and hologram representing different time points were superimposed by means of an adjustable x-y stage. Occlusal surface detail was used as a reference for the superimposition. Positional changes of the upper incisors were detected as discrepancies between the cast and the hologram image [5].

The study of Tomie N. Campos and colabs compared the transmission of tensions in fresh, fixed and macerated dog mandibles in order to clarify the diversity of behaviour of bone tissues under dry and moist conditions. Double-exposure holographic interferometry was applied and holograms were obtained from 12 fresh hemi-mandibles under static load (control group), which were randomly assigned to 2 groups: 6 were fixed in 10% formalin and 6 were macerated. The specimens were submitted to the same initial force and their respective holograms were obtained. Analysis of the holograms showed that the fresh specimens transmitted significantly less tension than the fixed and macerated ones ($p<0.05$), and the tension direction was different. An average two-fold tension increment was observed in the experimental conditions. The holographic interferometry method was efficient in quantifying and qualifying tension transmission. However, depending on the type of analysis, the anatomical specimens must be fresh because macerated specimens will produce different results [6].

Holography has found a series of applications in dentistry such as the study of elastic deformations of soldered gold joints, qualitative studies of various dental structures, and the measurement of elastic deformation of prosthodontic appliances. In orthodontics, it has been used for the storage of dental casts, determination of tooth displacements, determination of centers of rotations of teeth and studies of deformation of human skulls after force application. It has also been used for estimation of stress and strain in the periodontal ligament and alveolar bone after orthodontic force application [7-9].

The aim of the study of F.R. Wouters and colabs was to develop a sensitive measuring method enabling direct evaluation of gingival swelling to be made as registered on dental casts. On two separate occasions, when different degrees of severity of gingival inflammation were present in the same subject, reversible hydrocolloid impressions were taken of the mandible. The casts obtained were located successively in identical three-dimensional relationships in a field of interference fringes generated by two intersecting beams of collimated helium-neon laser light, and were photographed. The evaluation of the moire pattern obtained directly by superimposition of the two images of the surface studied indicated that a decrease in gingival height of 0. 38 mm in the direction of the camera had occurred between the two occasions. The use of a computer-based image-processing system considerably

* email: minosinescu@yahoo.com; Tel.: 0040 722280132

improved the visibility of the pattern. The reproducibility of the impression technique, as well as the relocation and superimposing techniques, proved satisfactory at the moire resolution used (0.19 mm). The method has potential application in clinical experimental research, and therefore warrants further evaluation [10].

The study of V. Panduric and colabs. determined whether it was possible to detect deformations and fractures in dental hard tissues or in composite material from internal stresses using double-exposure holographic interferometry. On the proximal side of eight intact human permanent premolars, a direct Class II cavity was prepared and restored with a self-etching adhesive (Clearfil SE Bond) and Tetric Ceram, a resin composite. In five of the specimens, Tetric Flow was used as an elastic layer. The samples were illuminated using a helium-neon laser beam, and the holograms of samples were recorded using Agfa 10E75 photographic plates. Hologram reconstructions were captured with an 8-bit monochrome CCD camera and qualitatively analyzed. Deformations and fractures appeared as fringe patterns on all interferograms, where the distribution of fringes provided location information, while the density of fringes gave the amplitude information. Greater fringe densities were observed in samples treated without a flowable composite [11] .

Experimental part

Two dental model casts were used for this study. The first model was obtained after the impression of the maxillary arch of the patient. After six month of this episode another dental impression was taken for the same maxillary arch and the second model was cast.

The holographic system was used to record and compare the two models mentioned before (fig. 1). For the first model a hologram was recorded on a usual holographic plate. The laser system used in the holographic recording was a He-Ne with 1 mV. Holography is a technique which enables a light field, which is generally the product of a light source scattering off objects, to be recorded and later reconstructed when the original light field is no longer present (due to the absence of the original objects). A hologram requires a laser as the light source, since lasers can be precisely controlled and have a fixed wavelength, unlike white light, which contains many different wavelengths.

Fig. 1. Frontal view of the holographic system used in this study

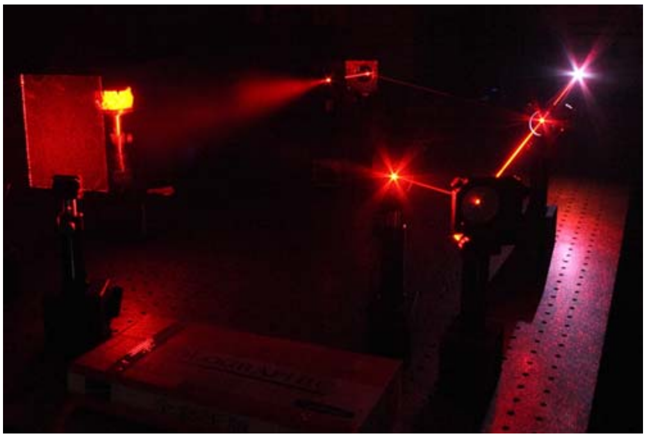

Fig. 2. Aspects from the recording process of the hologram for the considered dental cast.

A shutter is required when taking a photograph to limit the time in which the film is exposed to light. Holography also requires a specific exposure time, and this can be done using a shutter, or by electronic timing of the laser. This laser beam is generally aimed through a series of elements that change it in different ways (fig. 2). The first element is a beam splitter, which divides the beam into two identical beams, each aimed in different directions:

- one beam, known as the illumination or object beam, is spread using lenses and directed onto the scene using mirrors, in order to illuminate it. Some of the light scattered (reflected) from this illumination falls onto the recording medium;

- the second beam, known as the reference beam, is also spread through the use of lenses, but is directed so that it doesn't come in contact with the scene, and instead travels directly onto the recording medium.

On the recording medium, the light waves of the two beams intersect and interfere with each other. It is this interference pattern that is imprinted on the holographic medium. The pattern itself is seemingly random, as this pattern represents the way in which the scene light interfered with the original light source, but not the original light source itself. The interference pattern can be said to be an encoded version of the scene, requiring a particular key, that is, the original light source, in order to view its contents. This missing key is provided later by shining a laser, identical to the one used to record the hologram, onto the developed film which then recreates a range of the scene original light. When the original reference beam illuminates the hologram, it is diffracted by the recorded hologram to produce a light field which is identical to the light field which was originally scattered by the object or objects onto the hologram (fig. 3). When the object is removed, an observer who looks into the hologram "sees" the same image on his retina as he would have seen when looking at the original scene. This image is known as a virtual image.

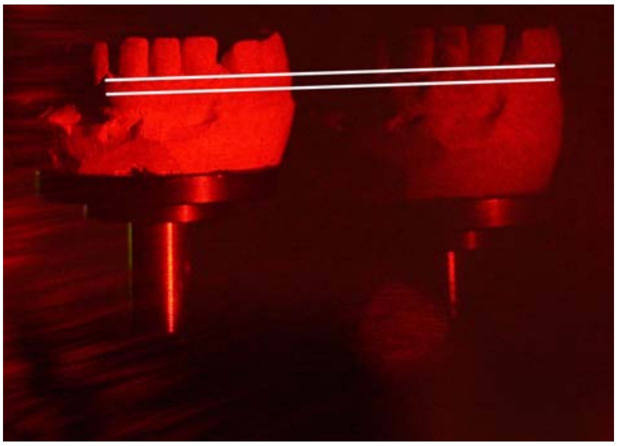

Fig. 3. Aspect of the gingival retraction pointed out by the white lines that are referred to the gingival margins on the second model cast (left) and on the hologram of the first model (right)

Results and discussions

Each point in the holographic recording includes light scattered from every point in the scene, whereas each point in a photograph has light scattered only from a single point in the scene which has been focused by a lens onto the film or the digital capture medium.

A hologram differs from a photograph in several ways:

- the hologram allows the recorded scene to be viewed from a wide range of angles whereas the photograph gives only a single view;

- the reproduced range of a hologram adds many of the same depth perception cues that were present in the original scene, which are again recognized by the human brain and translated into the same perception of a three-dimensional image as when the original scene might have been viewed. The photograph is a flat two-dimensional representation;

- the developed hologram surface itself consists of a very fine, seemingly random pattern, which appears to bear no relationship to the scene which it has recorded. A photograph clearly maps out the light field of the original scene;

- when a photograph is cut in pieces, each piece shows only part of the scene. When a hologram is cut in pieces, the whole scene can still be seen in each piece;

- a photograph can be viewed in a wide range of lighting conditions, whereas holograms can only be viewed with very specific forms of illumination.

Conclusions

Noninvasive evaluations methods, like holographic approach could be used in quantitative and qualitative evaluation of the retraction of the gingival margins.

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