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THE USE OF HOLOGRAPHIC TECHNIQUES TO OBTAIN MOIRÉ TOPOGRAPHIC FRINGES OF THE HUMAN BODY

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INTRODUCTION

The establishment of a workable system for early detection and treatment of back deformity is now being recognized as one of the major health problems for our society. Recently mass screening of back deformity has been widely conducted, based on visual inspections mainly consisting of the detection of a hump by a forward bending test and inspection of the shoulders, scapula, and lumber region for the left-right asymmetry. However, some of the criteria for identifying the normal and abnormal are not very distinct and the possibility of errorrs in judgement by individual examiners can be very great. This can result in confusingly different rates of back deformity detection in different places. Thus the problem now faced is the development of a more accurate and objective screening method.

An evaluation method to be used in both physiotherapeutic and

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orthopedic clinics which objectively reveals the effects of physiotherapeutic treatment is looked for. However, there has been no available method which can express the shape of a back surface with accuracy.

To improve the situation, the problem we are facing at present is the development of a more accurate and objective screening method. The principal conditions that must be satisfied by such a new method should be an absence of damage caused by X ray, accuracy and objectivity, ease and quickness. This led the authors to experiment with the holographic technique, for the purpose of applying it to the evaluation of treatment in cases of back deformities.

THEORY

Methods of moiré topography can be broadly divided into shadow and projection types, the projection method was announced by Suzuki et al. in 1972. The advantages of this method compared to the shadow method are as follows:

(a) The apparatus can be small and portable since gratings are set in the machine.

(b) Gratings can changed easily and any size of grating pitch that determines moiré fringe interval can be chosen.

(c) The position of the child is less restricted by grating.

(d) The measurement depth is deep enough so that this method is suitable for an object with great depression and elevation.

(e) The variation grating can be taken out, and further application such as grating hologram method is possible.

As shown in Fig. 1, which illustrates how the hologram interference

pattern is originally photographed and how an image is reconstructed using laser light. In the top drawing it will be seen that the laser beam is caused to divide, so that portion of the beam illuminates the object to be photographed, and a portion is reflected from a mirror to the photographic plate. If the beam from the mirror is not present, the light reflected from the object will, more or less, uniformly expose the photographic plate and no interference pattern will be recorded. However, with the reference beam from the mirror present; at each point on the plate an interference pattern will exist.

This interference pattern contains all the information about the object that is, each point on the object reflects light over all portions of the plate, and the intersection of these reflected rays with the reference rays produces a unique interference pattern at that point. The contrast of the fringes is related to the amplitude of the reflected light rays from the object with respect to the reference beam rays. The spacing of the fringes is related to the phase, or the angle between the object rays and the reference rays.

METHODS

Thirteen children participated in this study. A 4 x 5 inch format polaroid pack for instant image production was used. Type 55 polaroid film was selected to allow both an instant positive image and a permanent negative for further study. For illumination two 1000 watt outdoor spot lights collimated through 5 cm were used. Two laser beams of type 155 were fixed at an angle of 45°. All components were held in a fixed position by a rigid frame which also incorporated a darkening

curtain.

Subject positioning was achieved by having the subject stand looking straight ahead, arms at the side in a relaxed position. This was done as close as possible to the screen without actually touching it. No attempt was made to position the upper trunk except that the subject was asked to relax. The areas of asymmetry were identified by visual inspection. The level of maximum asymmetry for each of these asymmetric areas was judged and the fringe difference between two equidistant points on both sides of the midline determined.

RESULTS AND DISCUSSION

The mean initial moiré fringe asymmetry was 1.7 fringe in the most deviant portion of the back. Significant change in the moire photograph was defined as an increase in asymmetry of one or more fringe interval. Emergence of an asymmetry of one or more fringe intervals in an area previously symmetric was regarded as significant and a change in side of asymmetry also regarded as positive.

Using these criteria 13 subjects demonstrated both significant in their moiré photograph and hologram. 8 subjects showed significant changes in their photograph but insignificant (less than 5 degrees) in the hologram. None of them showed significant changes in the hologram with no significant change in moiré. If the moiré photograph is regarded as a true indicator of change in the two dimensional angle of spinal curvature, there were a total of 11 positive subjects (including 2 false positives) on the hologram. If the holography technique is to be used successfully in follow up of back deformities, the false negative rate

must be acceptably low. These results are indicative of this possibility.

No positioning device was used in this study. In the authors' opinion any constraining device tended to impose an abnormal posture on the subject. Positioning devices which alter the unihibited relationship between trunk and pelvis were not used because they might mask significant changes. The relatively high false positive rate may be due to lack of reproducible positioning and more experience will be required to see if either better positioning by the examiner or a positioning device which constrains only the pelvis will diminish the false positive rate.

CONCLUSION

Preliminary experience with moiré shadow photography using holography techniques are presented. This data suggests that holography used in the follow-up may be sufficiently accurate to partially supplement X rays in the physiotherapeutic follow-up of back deformities. More experience with longer follow-up is needed.

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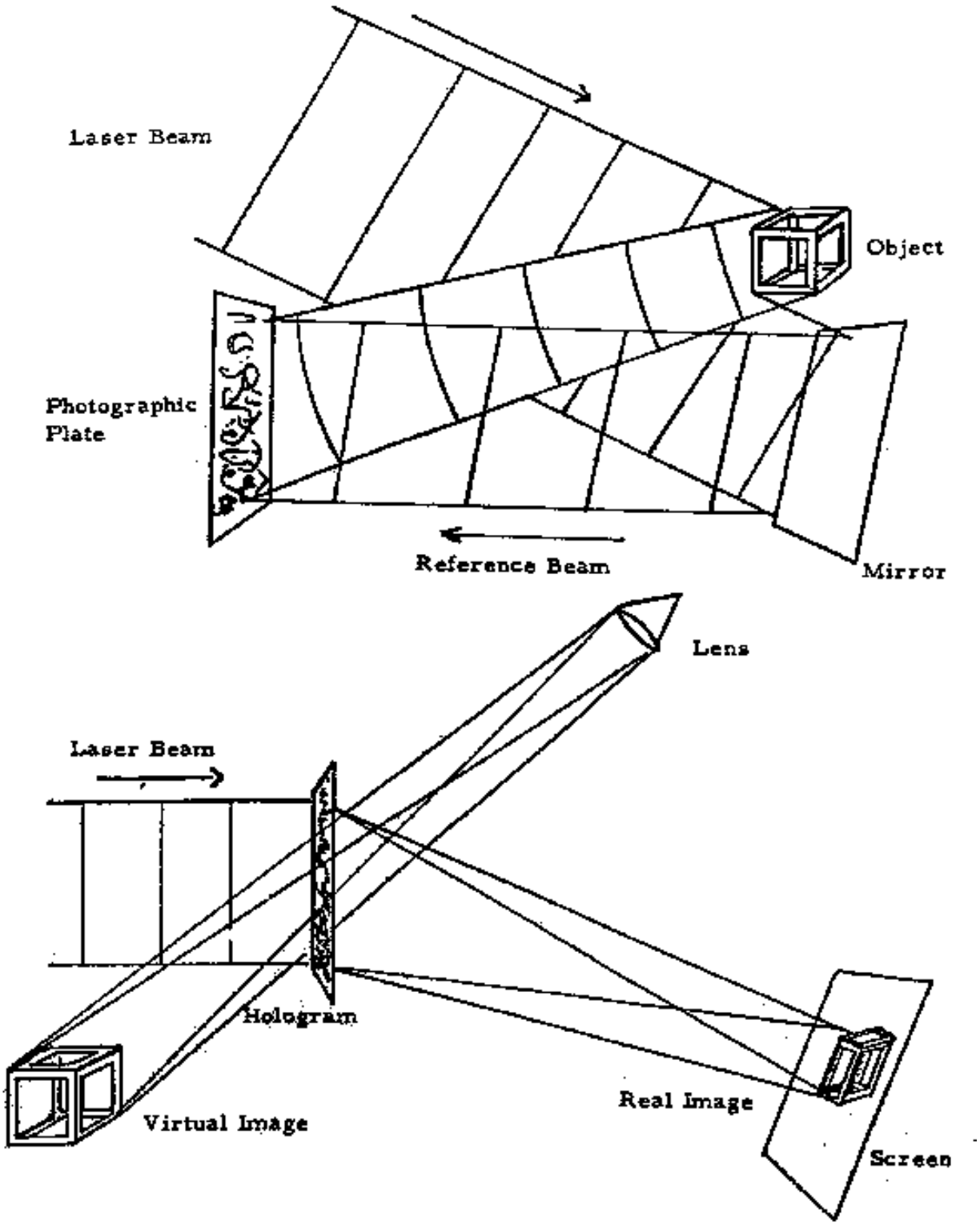

FIGURE 1: Principle of hologram.

FIGURE 2: Laser beam type 155 used in this study.

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