Pferdeheilkunde 12 (1996) 4 (Juli August) 679–680

A technical report on the distribution of strain in the hoof wall of a standing horse before and after trimming

Helen M. S. Davies

Equine Clinical Research Unit, Department of Veterinary Science, University of Melbourne, Australia

Summary

A photoelastic method used for materials testing in industry has been adapted to show the distribution of strain through the hoof wall in the living horse. Coloured fringes appear in the photoelastic plastic where there are strain gradients occurring in the hoof. Strain distribution was documented in the hoof wall of the left front limb in a standing horse before and after trimming. The concentration of fringes coincided with an area that was already showing the effects of unequal strain distribution in the cracking back of the hoof wall to the edge of the line where the fringes ceased. There were no concentrations of coloured fringes visible following trimming of the hoof.

Keywords: hoof wall, strain, horse, standing

Belastungsverteilung in der Hufwand eines stehenden Pferdes vor und nach der Hufkorrektur

Eine photoelastische Methode, die im industriellen Bereich in der Materialkontrolle angewandt wird, wurde verwendet, um am lebenden Pferd die Verteilung der Belastung in der Hufwand zu zeigen. An Stellen, an denen Belastungsunterschiede im Huf auftreten, zeigen sich in dem photoelastischen Kunststoff gefärbte Streifen. Die Verteilung der Belastung in der Wand des linken Vorderhufes eines stehenden Pferdes vor und nach der Hufkorrektur wurde aufgezeichnet. Die beobachtete Konzentration von Streifen stimmte mit einer Stelle überein, an der bereits Anzeichen einer ungleichmäßigen Belastung der Hufwand in Form von Spalten bis zu der Höhe, in der die Streifen endeten, zu sehen waren. Nach der Hufkorrektur war keine Konzentration gefärbter Streifen mehr zu erkennen.

Schlüsselwörter: Hufwand, Belastung, Pferd, stehend

Introduction

The forces involved in locomotion in normal horses are transmitted through the wall of the hoof. At present there is minimal information in the scientific literature on the pattern of loading across the wall of the horse's hoof. The effects of shape, shoeing techniques, nail holes and other defects on the pattern of strain are not known. This is because there has been no direct way to document the distribution of forces through the hoof wall in the living horse.

Several indirect methods of measuring the distribution of the vertical forces during locomotion using varied types of instrumented shoes and force transducers have been reported (*Barrey* 1990, *Frederick* and *Henderson* 1970, *Hjerten* and *Drevemo* 1986, *Ratzlaff* et al. 1985). These methods do not show what is happening to the hoof wall itself.

Direct measurement has been attempted using strain gauges (*Colles* 1989, *Preuschoft* 1989) but the placement of these transducers is somewhat arbitrary and they can only show the strain occurring in their immediate vicinity. In vitro testing of hoof material has shown that it is anisotropic in its material properties as well as varying in structure at different sites in the hoof wall (*Leach* and *Zoerb* 1983). The distribution of force through the hoof wall is therefore likely to be complex.

A photoelastic method used for materials testing in industry was adapted for use on the living hoof wall to show the distribution of strain.

Materials and methods

A single sound Thoroughbred mare that had not had her hooves trimmed in the previous 4 months was used.

The left front hoof was cleaned. A fast curing vinyl polysiloxane impression material putty (3M Express STD 7312, 3M Dental Products, MN., USA) was moulded around the hoof wall while the horse was standing with this hoof supported in a raised position. The putty was then removed and this negative cast of the hoof filled with a non-shrinking modified Plaster-of Paris (Polyfilla interior, Poly Products, NSW) to provide an accurate positive cast of the hoof wall.

Photoelastic material (PL-2 Liquid Plastic, Measurements Group Inc., Raleigh, NC, USA) was prepared and moulded to the Polyfilla cast in order to fit the hoof wall exactly.

The hoof was carefully cleaned and then washed with 70% alcohol. The hoof was then coated with a thin spray of silver paint. Adhesive (Supaglue, Selleys Chemical Co. Pty. Ltd.,

NSW, Australia) was then used to stick the plastic coating onto the hoof.
The coated hoof was observed through a polarising filter. Any coloured lines observed represented strain gradients (fringes) in the coating directly transferred from the hoof wall. The preparation was then photographed to provide a permanent record of the pattern of strain.
The hoof was trimmed with the coating in situ. The preparation was then observed and any fringes noted. The area was photographed.
The coating was then peeled off the hoof and the horse returned to the paddock.

Results

Before trimming the hoof, concentrated fringes occurred in the area where the toe of the hoof appeared long (Fig. 1). The proximal edge of these fringes coincided with the extreme edge of cracks that had already occurred in this region of the hoof wall.
There were no concentrations of coloured fringes in the photoelastic coating in the standing horse following trimming.
No further cracks occurred in this hoof in the month following this experiment.

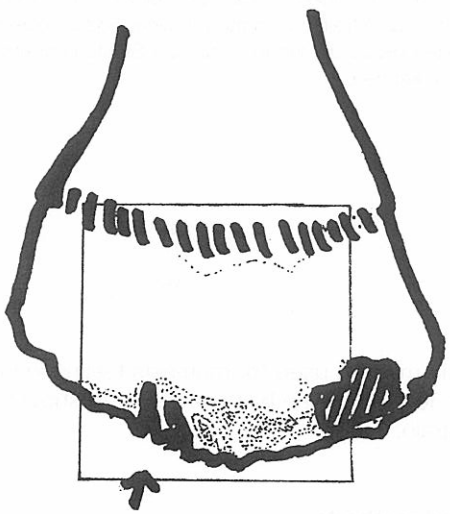

Fig. 1: Dorsomedial view of the distribution of strain in the left fore hoof of a standing horse as shown by photoelastic coating within the area marked by the square. The horse was standing with the weight evenly distributed between the two front limbs. The hoof was long in the toe and had begun to crack at the edge as shown by the arrow. The position of coloured fringes (isochromatics) are shown by the dotted lines. A piece of dung obscured some of the view and is shown as the hatched area.

Discussion

These preliminary results show that the strain distribution in the living hoof wall can be documented using a photoelastic technique. The concentration of fringes coincided with an area that was already showing the effects of unequal strain distribution in the cracking back of the hoof wall to the edge of the line where the fringes ceased.
The lack of any visible fringes following trimming suggests that the forces involved in standing were distributed evenly through the hoof wall at this time. The trimming not only reduced the strain gradients in the hoof, but was successful in preventing further cracks developing in this hoof.
The procedure required the horse to stand quietly with one hoof raised for 5 minutes while the impression material hardened, and subsequently to remain still for a further 5 minutes to attach the plastic coating with adhesive.
These findings demonstrate the potential use of the photoelastic method in the investigation of hoof wall loading in the living horse.

References

Barrey, E. (1990): Investigations of the vertical hoof force distribution in the equine forelimb with an instrumented horseboot. Equine Vet. J. Suppl. 9, 35–38.
Colles, C. (1989): A technique for assessing hoof function in the horse. Equine Vet. J. 21, 17–22.
Frederick, F. and Henderson, J. (1970): Impact force measurement using preload transducers. Am. J. Vet. Res. 31, 2279–2283.
Hjerten, G. and *Drevemo, S.* (1986): A method to analyse forces and moments in the extremities of the horse during the stance phase at the trot. Proceedings of the 2nd International Conference on Equine Exercise Physiology, San Diego, USA. p587–598.
Leach, D. and *Zoerb, G.* (1983): Mechanical properties of equine hoof wall tissue. Amer. J. Vet. Res. 44, 2190–2194.
Preuschoft, H. (1989): The external forces and internal stresses in the feet of jumping horses. Z. Säugetierkunde 54, 172–190.
Ratzlaff, M., Frame, J., Miller, L., Kimbrell, J. and *Grant, B.* (1985): A new method for repetitive measurement of locomotor forces from galloping horses. Proceedings of the 9th Equine Nutrition and Physiology Symposium, East Lansing, USA. p260–265.

Acknowledgements
This work was supported by funds from the Australian Equine Research Foundation.

H. M. S. Davies

Equine Clinical Research Unit,
Department of Veterinary Science,
University of Melbourne,
Prices Highway, Werribee,
Victoria, 3030, Australia.