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Original article

Comparison of the characteristics in hen and quail corneas as experimental models of refractive surgery^{☆,☆☆}



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ABSTRACT

Aim: To compare the histological, morphological and the biophysical measurements between hen and quail corneas, in order to determine which of them were better suited for use as an animal model for research into corneal refractive surgery.

Material and methods: A study was performed using the biophysical measurements of the cornea (curvature, thickness, refraction, and axial length) of 20 animals (10 hens and 10 quails). The corneas were then prepared for histological analysis under microscopy light.

Results: The analysis showed that both groups have the same number of corneal layers as the human cornea and with an evident Bowman's layer. The thickness of the hen cornea and axial length of the eye, $225.3 \pm 18.4 \mu\text{m}$ and $12.8 \pm 0.25 \text{ mm}$, respectively, were larger than that of the quail ($p < 0.01$ and $p < 0.001$, respectively). The radius of curvature for the hen central cornea, $3.65 \pm 0.08 \text{ mm}$, was greater than that for the quail ($p < 0.001$), but the refractive power of each cornea was similar. The proportion of total corneal thickness of the hen stroma, 82.6%, was more similar to that of the human than was the quail stroma, 72.5%. Within the hen stroma, the density of keratocytes, 8.57 ± 1.49 per $5000 \mu\text{m}^2$, was about half that in the quail stroma ($p < 0.005$).

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Conclusions: Because of the large size of the hen cornea, the stromal thickness and proportional similarity of the corneal layers with human cornea, the hen maybe better than the quail as an alternative species suitable for use in studies of corneal refractive surgery.

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Comparación de las características corneales en gallina y codorniz como modelos experimentales de cirugía refractiva

R E S U M E N

Palabras clave:

Córnea
Cirugía refractiva
Gallina
Codorniz
Bowman

Objetivo: Analizar y comparar la histología, la morfología y las medidas biofísicas corneales de la gallina y la codorniz para determinar qué modelo experimental animal es el más adecuado para la realización de estudios de investigación en cirugía corneal.

Material y métodos: Se estudiaron las medidas biofísicas de la córnea (curvatura, espesor, refracción y longitud axial) de 20 animales (10 gallinas y 10 codornices). Después las córneas fueron procesadas para el estudio de histología clásica bajo la luz del microscopio.

Resultados: Los 2 grupos analizados poseen una córnea similar a la del humano con respecto al número de capas y con una evidente capa de Bowman. El espesor corneal, así como la longitud axial del ojo de la gallina, $225,3 \pm 18,4 \mu\text{m}$ y $12,8 \pm 0,25 \text{ mm}$, respectivamente, fueron significativamente mayores que los de la codorniz ($p < 0,01$ y $p < 0,001$). El radio de curvatura de la córnea central de la gallina también fue significativamente mayor que el de la codorniz ($p < 0,001$). El poder refractivo de las 2 especies fue similar. La proporción del espesor estromal con relación a la córnea en la gallina fue más similar al humano (82,6%) que de la codorniz (72,5%). La densidad de la población de queratocitos en la gallina, $8,57 \pm 1,49/5.000 \mu\text{m}^2$, correspondió a cerca de la mitad del número de queratocitos encontrados en la córnea de la codorniz ($p < 0,005$).

Conclusiones: La córnea de gallina, por su tamaño, espesor del estroma y similitud de proporción en sus capas con la córnea humana, es más adecuada para la cirugía refractiva corneal que la de codorniz.

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Introduction

Refractive surgery covers a series of techniques whose use has experienced a boom in recent years. However, the speed with which it has spread and the young average age of patients operated on have meant limited knowledge of the histological and physical changes produced. To further our knowledge in this area of ophthalmology, it is therefore necessary to resort to the development of animal models that reproduce the condition as closely as possible with controlled variables and efficacy and safety measurement parameters which, for obvious reasons, cannot be carried out in humans.

The various procedures applied in surgery all involve the cornea as the main structure, as it is the main refractive element in the eye. Refractive surgery studies have been conducted on different laboratory animals, such as rabbit,¹ rat² and monkey.³ However, for the study of corneal surgery, the use of birds is attractive because they have similarities with the human cornea; our group began to use birds as animal models in refractive surgery in 2001.⁴

The main reason for our choice is that, like humans, the hen cornea has 5 layers.⁴⁻⁶ The stromal layer accounts for

approximately 90% of the total thickness and maintains a degree of regularity in the positioning of its collagen fibres in the central zone.^{2,7,8} That positioning of collagen fibres also allows avian cornea to be transparent from day 18 of corneal development.⁸⁻¹⁰ This is because the blood-aqueous barrier is extremely stable.⁶ Bowman's layer is of a similar thickness to that of the human cornea and it plays an important role in the healing response and biomechanics in refractive surgery due to direct interaction between the epithelial and stromal cells.⁴⁻⁶ The 5 layers are important but are not the only reason for choosing hens; they are also an economical animal model, easy to handle, easy to anaesthetise, have little inflammatory response, rarely become infected and do not require complicated maintenance.

However, the hen is not one of the experimental models represented in Appendix VII of Royal Decree 1201/2005, in which quails are the only birds accepted for animal experimentation, and prior express authorisation is therefore required before hens can be used in research.

The objective of this study was therefore to analyse and compare the measurements of the corneal characteristics of the Lohman Classic hen and the quail from a histological, morphological and biophysical point of view, to determine which

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