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ORIGINAL ARTICLE

Accuracy of Cirrus HD-OCT and Topcon SP-3000P for measuring central corneal thickness

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Abstract
Purpose: To compare and analyze the interchangeability of three measuring systems, each based on a different technique, for central corneal thickness (CCT) analysis.
Methods: CCT measurements were measured using optical coherence tomography (OCT), non-contact specular microscopy (NCSM), and ultrasonic pachymetry (USP) in 60 eyes of 60 healthy patients with a mean age of 66.5 ± 15.0 years and a mean spherical equivalent of 0.43 ± 1.14 D. Analysis of variations in measurement concordance and correlation among the three different methods were performed. Comparison of CCT measurements were done using Bland–Altman plots (with bias and 95% confidence intervals), intraclass correlation coefficient (ICC), and paired *t*-student analysis.
Results: Mean CCT values were: $549.20 \pm 26.91\,\mu$m for USP (range $503–618\,\mu$m), $514.20 \pm 27.49\,\mu$m for NCSM (range $456–586\,\mu$m) and $542.80 \pm 25.56\,\mu$m for OCT (range $486–605\,\mu$m). CCT values obtained with NCMS were significantly lower than those obtained with OCT and USP methods. NCMS CCT value was $36.08 \pm 10.72\,\mu$m lower than USP value ($p < 0.05$), and NCMS CCT value was $7.88 \pm 8.86\,\mu$m lower than OCT value ($p < 0.05$). ICC between USP–NCSM pair was 0.488 and 0.909 between USP–OCT pair.
Conclusion: OCT and UPS offered highly comparable results, whereas NCSM offered lower mean CCT values compared to the other two methods. Therefore, NCSM should not be considered a reliable method for measuring CCT and should rather be considered for assessing longitudinal changes in the same patient.
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PALABRAS CLAVE
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Precisión de Cirrus HD-OCT y Topcon SP-3000P en la medición del espesor corneal central

Resumen

Objetivo: Comparar y analizar la intercambiabilidad de tres sistemas de medición, basado cada uno de ellos en una técnica diferente, para estudiar el espesor corneal central (ECC).

Métodos: Se realizaron mediciones del ECC utilizando tomografía de coherencia óptica (OCT), microscopía especular (NCSM), y paquimetría ultrasónica (USP) en 60 ojos de 60 pacientes sanos, con una edad media de $66,5 \pm 15$ años y un equivalente esférico medio de $0,43 \pm 1,14$ D. Se realizaron análisis de las variaciones de concordancia de las mediciones, y correlación entre los tres métodos diferentes. Se compararon las mediciones del EEC utilizando gráficos de Bland-Altman (con desviaciones, e intervalos de confianza del 95%), coeficiente de correlación intra-clase (ICC), y análisis de t pareada de Student.

Resultados: Los valores medios de ECC fueron: $549,2 \pm 26,91\,\mu m$ para USP (rango 503-618 μm), $514,2 \pm 27,49\,\mu m$ para NCSM (rango 456-586 μm) y $542,8 \pm 25,56\,\mu m$ para OCT (rango 486-605 μm). Los valores de ECC obtenidos con NCMS fueron significativamente inferiores que los obtenidos con los métodos OCT y USP. El valor de ECC obtenido mediante NCMS fue inferior en $36,08 \pm 10,72\,\mu m$ al valor obtenido mediante USP ($p < 0,05$), y el valor de ECC obtenido mediante NCMS fue inferior en $7,88 \pm 8,86\,\mu m$ al obtenido mediante OCT ($p < 0,05$). El ICC entre el par USP-NCSM fue de 0,488, y de 0,909 entre el par USP-OCT.

Conclusión: Los métodos OCT y UPS aportaron resultados altamente comparables, mientras que NCSM aportó unos valores medios de ECC inferiores a los aportados por los otros dos métodos. Por tanto, NCSM no debería considerarse un método fiable en la medición del ECC, debiéndose utilizar en la valoración de los cambios longitudinales del mismo paciente.

Introduction

Central corneal thickness[1–3] measurement is required for several procedures in ophthalmology such as corneal dystrophy follow-up, contact lens wear complications, glaucoma and postoperative studies after corneal surgery.[1,4–6]

Ultrasonic pachymetry (USP) instruments measure the CCT by, emitting short electrical pulses which are transformed into ultrasonic waves by a crystal probe at 20 MHz frequency and 1640 m/s speed. The measurement is performed between the corneal epithelium and Descemet's membrane. Due to the high reproducibility this technology is currently considered as the Gold Standard.[7–13,18] However, CCT measurements with USP depend on a highly accurate location and positioning of the probe (orthogonal to the corneal surface). At the same time, USP requires local anaesthetic eye drop instillation as some corneal indentation occurs because of probe contact. Some authors suggest that CCT values may be altered by up to 10 μm because of corneal anaesthesia instillation.[7]

Besides USP, other techniques offer the possibility of measuring CCT by direct methods. Among them, anterior segment optical coherence tomography (15) offers fast and non-contact CCT measurement by analysing infrared interferometry.[14] It uses a 1310 nm diode light with a rate of 4000 scans/s to scan captured images. The OCT device captures a corneal sectional image, which is then analyzed by software. In this case, the CCT value is calculated from tear film to corneal endothelium.[15]

Non-contact specular microscopy (NCSM) is commonly used for studying the number, shape and size of endothelial cells,[16] but can be used to measure CCT values. In NCSM technology, images and corneal thickness values, are obtained by photographic cell reflection acquisition, where each interface (tear film, corneal epithelium and aqueous humour) causes a light reflection due to a different refractive index. NCSM technology obtains CCT values by considering the space between the tear film and the corneal endothelium.[17]

Both OCT and NCSM systems use optical technologies and do not require anaesthetic drop instillation. Therefore, the advantages of optical systems are a faster data acquisition and a fewer inherent complications related to corneal contact.

The existence of different CCT measurement methods makes it important to understand their strengths and weaknesses. In this respect, some studies have compared different methods for calculating CCT values,[6,16,18,19] and substantial progress has been made in this field. One study[2] has previously analyzed the inter-instrument reproducibility of CCT measurement using USP, slit-lamp optical coherence tomography and specular microscopy, but Cirrus HD-OCT has greater axial and transversal resolution. Furthermore no statistical tests have been properly used to quantify the agreement among the three different instruments. Consequently, at present it is not easy to know if CCT values obtained with different instruments are comparable and equivalent.