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## Original article

# Agreement between intraoperative measurements and optical coherence tomography of the limbus-insertion distance of the extraocular muscles<sup>☆</sup>

L. de-Pablo-Gómez-de-Liaño<sup>a,\*</sup>, J.I. Fernández-Vigo<sup>b</sup>, N. Ventura-Abreu<sup>b</sup>,  
L. Morales-Fernández<sup>b</sup>, J. García-Feijóo<sup>b</sup>, R. Gómez-de-Liaño<sup>b</sup>

<sup>a</sup> Departamento de Oftalmología, Complejo Asistencial de Ávila, Ávila, Spain

<sup>b</sup> Departamento de Oftalmología, Hospital Universitario Clínico San Carlos, Instituto de Investigación Sanitaria (IdISSC), Madrid, Spain

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## ABSTRACT

**Objective:** To assess the agreement between intraoperative measurements of the limbus-insertion distance of the extraocular muscles with those measured by spectral domain optical coherence tomography.

**Methods:** An analysis was made of a total of 67 muscles of 21 patients with strabismus. The limbus-insertion distance of the horizontal rectus muscles were measured using pre-operative SD-OCT and intra-operatively in 2 ways: (1) direct, after a conjunctival dissection in patients who underwent surgery, or (2) transconjunctival in patients who were treated with botulinum toxin, or in those who were not going to be operated. The intraclass correlation coefficient and Bland-Altman plots were calculated to determine the concordance between the 2 methods.

**Results:** The mean age was  $45.9 \pm 20.9$  years (range 16 to 85), with 52% being women.

The percentage of identification by direct intraoperative measurement was 95.6% (22/23), by transconjunctival intraoperative measurement 90.9% (40/44), and by OCT 85% (57/67), with 22 muscles finally being analyzed for the agreement study between direct intraoperative measurement and OCT measurements, and 35 muscles for the agreement between transconjunctival intraoperative measurement and OCT. The intraclass correlation coefficient showed good agreement with OCT and direct intraoperative measurements (0.931; 95% confidence interval (95% CI): 0.839–0.972;  $P < .001$ ), and with transconjunctival intraoperative measurements (0.889; 95% CI: 0.790–0.942;  $P < .001$ ).

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\* Corresponding author.

E-mail addresses: [depablo.lucia@gmail.com](mailto:depablo.lucia@gmail.com), [kinga84@hotmail.com](mailto:kinga84@hotmail.com) (L. de-Pablo-Gómez-de-Liaño).

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*Conclusions:* The SD-OCT is an effective technique to measure the distance from the insertion of the horizontal rectus muscles to the limbus, with a high agreement with intraoperative measurements being demonstrated.

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## Concordancia de la distancia desde la inserción hasta el limbo de los músculos rectos entre la medida intraoperatoria y con tomografía de coherencia óptica

### R E S U M E N

#### Palabras clave:

Tomografía de coherencia óptica  
Músculos extraoculares  
Estrabismo  
Inserción de rectos horizontales  
Distancia inserción-limbo

*Objetivo:* Valorar la concordancia entre la medida intraoperatoria y mediante tomografía de coherencia óptica de dominio espectral (SD-OCT) de la distancia desde la inserción muscular de los rectos horizontales hasta el limbo.

*Métodos:* Se analizaron 67 músculos de 21 pacientes con estrabismo. La distancia inserción-limbo de los músculos rectos horizontales fue medida mediante SD-OCT y de forma intraoperatoria de 2 maneras: 1) directa, tras la apertura de la conjuntiva en los pacientes en los que se realizó cirugía; 2) transconjuntival, en aquellos que fueron tratados con toxina o en músculos que no iban a ser intervenidos. Se calculó el coeficiente de correlación intraclase y se realizó un análisis de Bland-Altman para determinar la concordancia entre las medidas.

*Resultados:* La edad media fue  $45,9 \pm 20,9$  años (rango 16-85), con el 52% de mujeres. El porcentaje de identificación de manera intraoperatoria directa fue el 95,6% (22/23), mientras que transconjuntival fue el 90,9% (40/44) y mediante OCT fue de 85% (57/67). Fueron finalmente analizados para el estudio de concordancia 22 músculos mediante medida intraoperatoria directa y OCT y 35 mediante medida transconjuntival y OCT. El coeficiente de correlación intraclase mostró buena fiabilidad de la medida con OCT tanto con la medida intraoperatoria directa (0,931; intervalo de confianza al 95% (IC 95%): 0,839–0,972;  $p < 0,001$ ), como con la medida intraoperatoria transconjuntival (0,889; IC 95%: 0,790–0,942;  $p < 0,001$ ).

*Conclusiones:* La OCT de dominio espectral permite medir de una forma eficaz la distancia desde la inserción de los músculos rectos horizontales hasta el limbo esclerocorneal, con una elevada concordancia con la medida intraoperatoria.

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## Introduction

Extraocular rectus muscles insert in the sclera along the Tillaux spiral.<sup>1</sup> The distance of these muscles to the limbus varies between individuals and their importance has been studied for many years in strabology surgery.<sup>2,3</sup> In specific cases such as muscular fibrosis or in previously intervened patients, the insertion-limbus distance acquires greater relevance.

To date, different imaging technologies have been used for visualizing extraocular muscles such as nuclear magnetic resonance and computerized axial tomography.<sup>4-6</sup> Unfortunately, said devices lack precision and cannot be utilized for establishing the exact location of muscles insertions or to measure the distance to the limbus. In addition, they involve several disadvantages such as lack of availability in daily practice and high costs. In addition, computerized axial tomography is limited due to the radiation it involves. Other imaging technologies include echography which offers low resolution of

the insertion<sup>7,8</sup> and ultrasound biomicroscopy which provides higher resolution but is an invasive and uncomfortable procedure for patients, making it difficult to utilize in children without sedation or general anesthesia.<sup>9-12</sup>

In recent years, optical coherence tomography (OCT) has become an efficient alternative for identifying ocular rectus muscles, with the added benefit of being noninvasive and comfortable for patients, making it easy to use with children.<sup>13-17</sup>

The first published paper on the use of OCT for analyzing the distance of extraocular rectus muscle insertions was by Liu et al.,<sup>13</sup> which reported good matches with intraoperative measurements. In turn, Ngo et al.<sup>15</sup> also obtained good matches between OCT and intraoperative measurements for the insertion of horizontal and vertical rectus muscles, comprising patients with and without previous surgery. Recently, OCT has evolved from the time domain utilized by said authors to spectral domain, which has been applied in this study as it provides higher acquisition rates which translate into improved image resolution.

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