Eyelid eversion for visualisation of the upper eyelid lamellae: an anatomical cadaver study

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ABSTRACT

Controversy persists in surgical eyelid anatomy despite the routine use of microanatomical examination in modern eyelid research. The aim of our study was to facilitate visualisation of upper eyelid anatomy by optimising the orientation of cadaveric specimens. We studied the anatomy of everted eyelids, providing an excellent histological view of the posterior approach to the eyelid commonly used in surgery. Non-traumatic separation of the eyelid lamellae provides a new view of the eyelid's lamellar nature. Further application of this model may enhance understanding of the multilayered aspect of the levator aponeurosis. The technique may improve intraoperative understanding of critical eyelid anatomy and promote safer and more effective eyelid surgery.

INTRODUCTION

The anatomical arrangement of the levator palpebrae superioris muscle (LPS), its anterior lamella (the levator aponeurosis (LA)) and its posterior lamella (the Müller muscle (MM)) have historically been incompletely understood.[1 2] Knowledge of LPS anatomy is essential for safe and effective eyelid surgery. The gold standard for examination of eyelid anatomy has been the cadaveric model, which is classically studied in the sagittal plane. However, limited visualisation due to dissection technique,[3] distortion[4] and the close proximity of eyelid structures[5] has fuelled continued debate.

Given the limitations of using cadavers, some have tried newer imaging modalities, for example, surface coil MRI[6] and ultrasound biomicroscopy,[7] to further advance knowledge of surgical eyelid anatomy. Yet, in spite of its limitations, light microscopy study of cadaveric tissue generally provides superior resolution and remains one of the main approaches for study of the LPS and its lamellae.[3 5 6 8 9]

We report on how to optimise the classic use of cadaveric specimens by eversion of fresh upper eyelid tissue, secured by suture and formalin fixation, to non-invasively visualise the eyelid lamellae. We use the model to study the surgical microanatomy of the layers of the LA.

METHODS

Twenty-three orbits from 18 fresh-frozen cadaver heads were used. We everted the upper eyelids of 10 orbits from five heads (two male and three female; four Caucasian, one African-American; age range 54–82 years; mean age 69 years). To keep the eyelid everted during specimen handling and fixation, a 4-0 silk suture was placed through the grey line and secured above the eyebrow (figure 1). The eyelids of the remaining 13 orbits (four male and nine female; 13 Caucasian; age range 42–100 years; mean age 76 years) were left undisturbed as controls for anatomical comparison. The heads were fixed supine in 10% neutral buffered formalin for 3 weeks, exenterated and sutures removed. The orbits were sectioned parasagittally along the axis of the orbit and examined grossly. All specimens were cut in 6 μm sections, stained with Masson trichrome and studied histologically. Elastic stain was used as a counterstain[10] for the 10 everted and seven non-everted eyelids.

RESULTS

All eyelids maintained accurate positioning (figure 2A). The LA arose from the superior half of the LPS. The inferior half of the striated LPS fibres transitioned into the smooth-muscle fibres of the MM. A multilayered LA was well seen in all 10 everted eyelids (figure 2B,C) and five of 13 (38%) non-everted eyelids. The remaining non-everted eyelids had an equivocal or poorly visible monolayer LA arrangement (eight of 13; 62%). The lamellae in the everted eyelids were very clearly seen.

DISCUSSION

Our histological eyelid anatomy study is the first to be performed on the everted eyelid. Our approach is based on the eversion of fresh eyelid tissue, secured by suture and formalin fixation, with subsequent examination. The results revealed excellent exhibition of the lamellar characteristics of the eyelid anatomy. Eversion of the eyelid stretches the most posterior lamellae and relaxes the more anterior lamellae. It is the more anterior relaxed lamellae that are seen to separate from the taut posterior lamellae in our everted specimens.

Eyelid eversion is a commonly performed technique in clinical and surgical settings. Clinically, eversion is used for inspection of the palpebral conjunctiva, tarsus and fornix. Intraoperatively, the eyelid is everted for access to the posterior aspect of the eyelid. In some surgeries, such as the MM-conjunctival resection ptosis procedure, even when a Desmarres retractor is used to maximally evert the eyelid, the retractor is released prior to closing of the clamp.[11] Analysis of the everted eyelid sheds light on the orientation of the internal surgical anatomy and may lead to better understanding of common eyelid procedures.[10]

Cadaveric tissue is commonly used for the gross dissection and microscopic study of surgical eyelid

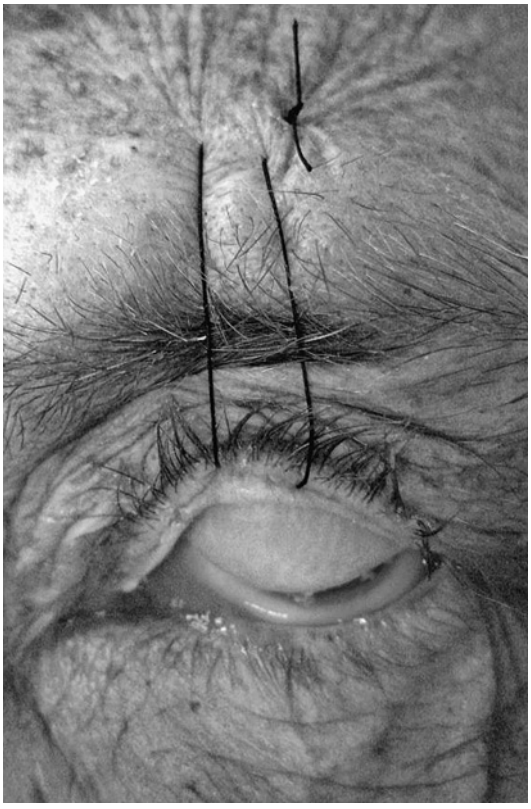

Figure 1 Anterior view of everted upper eyelid with retention suture.

anatomy, but dissection of specimens runs the risk of altering tissue planes. Furthermore, the close proximity and parallel course of the lamellae have caused difficulty in the study of eyelids in the classic sagittal orientation.[5] Artefacts may occur with the positioning, fixation and sectioning of the delicate tissues.[3 4] The limitations of the everted eyelid model potentially include the same artefacts of working with delicate tissues and thus the model is intended to broaden options rather than replace the classic approach.

In comparison with the classical approach, with eyelid eversion, the multiple layers of the LA separate. In the everted eyelid, the lamellae are more distinct because the superficial LA runs parallel with the tarsus, while the deep LA runs approximately perpendicular to the tarsus. The findings in our study are concordant with Anderson and Beard's 1977 description of a complex aponeurosis, with multiple layers having a 'fan of insertions' as shown in their grossly dissected eyelid specimens.[8] The challenges of the classical orientation may have played a role in more recent histological descriptions of the layers of the LA, which include the presence of a double-layered LA in all Asian eyelids but only one of 11 Caucasian specimens.[9] The everted eyelid model seems to more clearly demonstrate that the multilayered LA anatomy is shared not only by Asians, but also by African-Americans and Caucasians alike. However, an additional limitation of our study is that no Asian eyelids were examined and thus further studies using everted Asian eyelids would be necessary to exclude the possibility of anatomical variation. As common anatomy, it is interesting to consider that a multilayered LA may have a functional role in eyelid mechanics, rather than simply resulting in external phenotypic variation.

In summary, the everted eyelid model has several advantages over the classic sagittal orientation. First, the everted approach

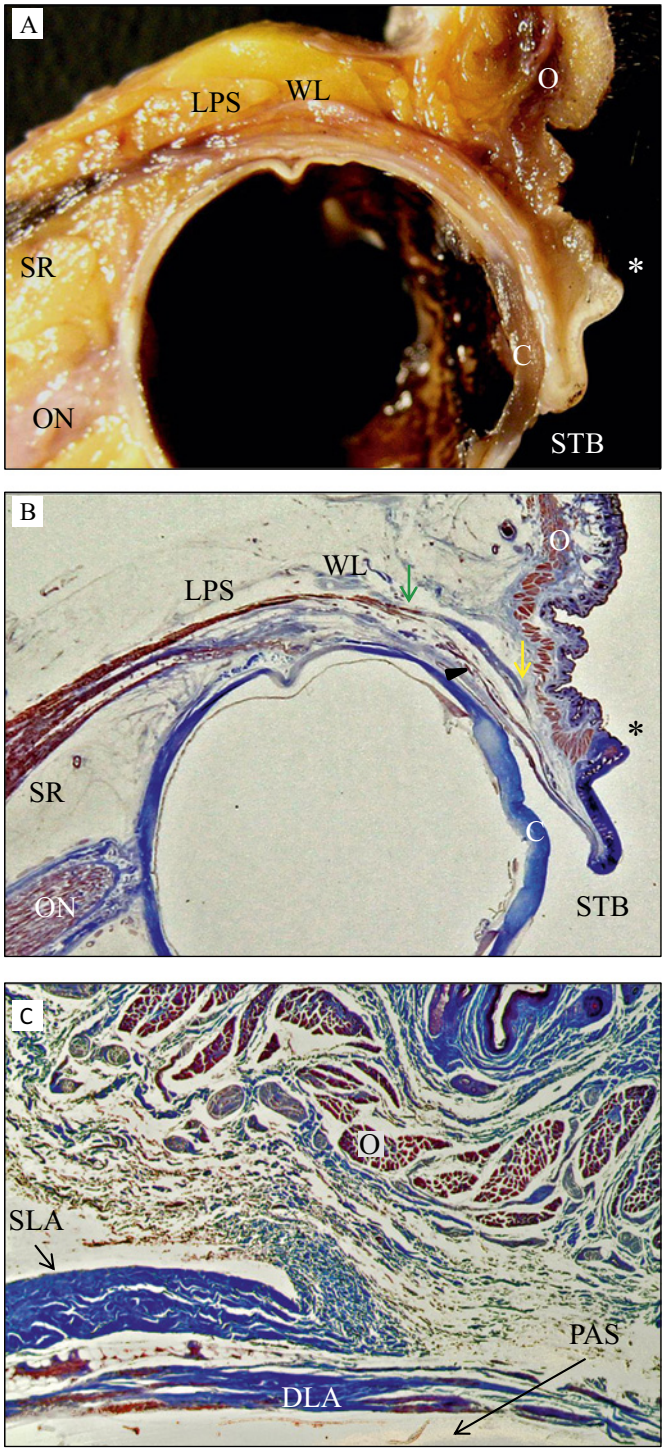

Figure 2 Parasagittal section (A) and photomicrograph (Verhoeff–Masson trichrome, original magnification ×1) (B) showing everted upper eyelid. Note that the superior tarsal border (STB) and eyelid margin (asterisk) are opposite to their normal anatomical positions. Vertical bifurcation of the striated muscle fibres of the levator palpebrae superioris (LPS, green arrow) into the multilayered levator aponeurosis (LA, yellow arrow) and Müller muscle (arrowhead) are demonstrated. Whitnall's ligament (WL), orbicularis oculi muscle (O), superior rectus muscle (SR), cornea (C) and optic nerve (ON) are also seen. The yellow arrow also designates the area shown in (C). (C) Photomicrograph (Verhoeff–Masson trichrome, original magnification ×40) showing distinct superficial (SLA) and deep (DLA) aspects of the multilayered LA. The SLA is relatively relaxed and diverges approximately perpendicular to the DLA. The orbicularis oculi muscle (O) and post-aponeurotic space (PAS) can also be seen.

provides clinicoanatomical correlation with the frequent procedures that include eyelid eversion. The technique we describe is relevant to understanding the clinical and surgical anatomy of a commonly performed manoeuvre. Second, the technique allows non-invasive separation of the eyelid lamellae, which permits improved visualisation of the lamellar aspect of eyelid retractor anatomy; an example is that it allowed us to establish the consistency of multilayered LA anatomy. Third, the eyelid eversion model provides a fresh perspective on anatomical relationships that have long been debated by surgeons. While the everted model is intended as an alternative rather than a replacement for the classic orientation, the broader benefits of facilitating further studies of surgical eyelid anatomy make the model particularly significant.

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Competing interests None.

Ethics approval The study was performed in compliance with the University of Chicago Institutional Review Board's policy on research on decedents. In addition, the study conformed to the principles of the Declaration of Helsinki.

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