MUC16 as a Sensitive and Specific Marker for Epithelial Downgrowth

Vicky C. Pai, MD; Ben J. Glasgow, MD

Objective: To compare immunohistochemical results of cytokeratin AE1/AE3, the traditional favored marker, with MUC16 and cytokeratin 19 for diagnostic sensitivity and specificity in epithelial downgrowth and control corneas.

Methods: Immunohistochemical analysis was performed in 5 cases of epithelial downgrowth and 5 control specimens for MUC16, cytokeratin AE1/AE3, and cytokeratin 19 using the immunoperoxidase method. The mean percentages of reactive cells on the epithelium and endothelium were compared for each antibody using the Wilcoxon rank sum test. The sensitivity and specificity for each marker were compared.

Results: All 3 antibodies showed high sensitivity (100%) in identifying epithelial downgrowth. However, the specificity was greatest for MUC 16 (100%) compared with cytokeratin 19 (80%) and cytokeratin AE1/AE3 (0%). None of the endothelial cells in any case showed reactivity to anti-MUC16 compared with anti–cytokeratin AE1/AE3 (mean [SD], 0.0% [0.0%] vs 17.4% [10.4%]; P = .008). Cytokeratin 19 was positive in every case of epithelial downgrowth but showed focal staining of the endothelium (3.4% of cells) in 1 control.

Conclusions: Antibodies for MUC16, cytokeratin AE1/AE3, and cytokeratin 19 are equally sensitive for downgrowth. However, anti-MUC16 showed superior specificity compared with anti–cytokeratin 19 or anti–cytokeratin AE1/AE3 in this study.

cessing. Specimens with multiple prior eye operations would cause processing was similar to the downgrowth specimens and mens of cases of keratoconus. These cases were selected be-
obtained from randomly selected penetrating keratoplasty speci-
MUC16 was found to be expressed in superficial layers of corneal epithelium even when thinned after exfoliation.8

**RESULTS**

Five control and 5 experimental corneal buttons were re-embedded in the same paraffin block with a positive control specimen of eyelid skin obtained from an exenteration. Immunohistochemical analysis was performed by the peroxidase-antiperoxidase technique, as previously described.5 Five-micrometer sections were deparaffinized in xylene, washed in graded alcohols, incubated for 13 minutes in TRIS-buffered sa-

**STATISTICAL ANALYSIS**

Data were analyzed for differences in the percentage of immu-
noreactive cells for anti-MUC16 vs anti–cytokeratin AE1/AE3 vs anti–cytokeratin 19 for cells on the epithelial and endothelial surfaces of both control and epithelial downgrowth speci-
mens. The Wilcoxon rank sum test was used for analysis. P < .05 was considered statistically significant. Sensitivity (S) and speci-
ficity (SP) were calculated as: 

\[ S = \frac{TP}{TP + FN} \]

\[ SP = \frac{TN}{TN + FP} \]

where TP=true positive, TN=true negative, FP=false positive, and FN=false negative cases of epithelial down-
growth.11

**IMMUNOHISTOCHEMICAL ANALYSIS**

All control corneal specimens showed immunoreactivity for MUC16, but limited to the superficial layers of epithelium. Anti–cytokeratin AE1/AE3 reacted with all epithe-

**CASE SELECTION**

Five histopathologically confirmed cases of epithelial down-
growth were obtained from 2006 to 2008. The clinical fea-
tures are listed in Table 1. Five control corneal buttons were obtained from randomly selected penetrating keratoplasty speci-
mens of cases of keratoconus. These cases were selected be-
cause processing was similar to the downgrowth specimens and the endothelium was abundant for cell counting. Prior studies have shown that cytokeratins are sensitive to fixation and pro-
processing. Specimens with multiple prior eye operations would have better matched the clinical histories of most cases with epithelial downgrowth. However, the prior procedures often leave exiguous endothelium, insufficient to obtain statisti-
cally valid results.

**METHODS**

**RESULTS**

All control corneal specimens showed immunoreactivity for MUC16, but limited to the superficial layers of epithelium. Anti–cytokeratin AE1/AE3 reacted with all epithelial layers in 3 of 5 control corneal specimens. The remaining 2 specimens showed reactivity of only the superficial and basal epithelial layers. Quantitative analy-
sis showed a lower percentage of positively stained epithe-

Table 1. Clinical Characteristics of Patients With Epithelial Downgrowth

<table>
<thead>
<tr>
<th>Patient No./Sex/Age, y</th>
<th>Eye Operations/Diagnoses Prior to Diagnosis of ED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/F/67</td>
<td>ACIOL, PKP, Ahmed valve</td>
</tr>
<tr>
<td>2/M/41</td>
<td>PKP, repeated PKP with corneal melt</td>
</tr>
<tr>
<td>3/M/75</td>
<td>PPV with hemorrhage</td>
</tr>
<tr>
<td>4/F/69</td>
<td>Chronic corneal perforation with conjunctival flap</td>
</tr>
<tr>
<td>5/M/49</td>
<td>RG repair, PPV, choroidal drainage</td>
</tr>
</tbody>
</table>

Abbreviations: ACIOL, anterior chamber intraocular lens; ED, epithelial downgrowth; PKP, penetrating keratoplasty; PPV, pars plana vitrectomy; RG, ruptured globe.

**Figure 1.** Failed Descemet stripping automated endothelial keratoplasty specimen demonstrating a thin layer of cells on the posterior corneal surface in a case of epithelial downgrowth (hematoxylin-eosin, original magnification ×250).
[SD], 19.5% [13.1%] (P = .02) (Figure 2). Anti–cytokeratin AE1/AE3 reacted with cells on both epithelial (mean [SD], 41.2% [37.7%]) and endothelial (mean [SD], 48.6% [42.0%]) surfaces of all epithelial downgrowth specimens. No significant differences were detected in the percentage of anti-MUC16–reactive cells vs cells stained with anti–cytokeratin AE1/AE3 compared on either the epithelial or endothelial surfaces of epithelial downgrowth specimens (Figure 3). Comparison of the sensitivity and specificity of the immunomarkers is shown in Table 2. All markers were sensitive for downgrowth, but MUC16 was more specific than cytokeratin AE1/AE3 and cytokeratin 19 for epithelial downgrowth specimens.

In 2 control specimens, anti–cytokeratin 19 reacted with cells in the superficial and basal epithelium. In 3 specimens, reactivity was confined to occasional cells in the superficial epithelium. The endothelium was positive in 1 specimen (3.4% of cells) for anti–cytokeratin 19. Quantitative analysis showed mean [SD] 3.4% [4.4%] of positively stained cells on the epithelial side and 0.7% [1.5%] of positively stained cells on the endothelial side of the control specimens. In epithelial downgrowth specimens, anti–cytokeratin 19 reacted with mean [SD] 20.0% [15.4%] of cells on the epithelial surface and 44.1% [43.7%] of cells on the endothelial surface. Anti–cytokeratin 19 reacted to a significantly greater percentage of cells on the endothelial side of control corneal and epithelial downgrowth specimens compared with control specimens (P = .02).

In controls, anti–cytokeratin 19 reacted with a lower percentage of epithelial cells (mean [SD], 3.4% [4.4%]) than anti–cytokeratin AE1/AE3 (mean [SD], 74.4% [61.2%]) (P = .008). Also, fewer endothelial cells were stained with anti–cytokeratin 19 in controls (mean [SD], 0.7% [1.5%]) compared with anti–cytokeratin AE1/AE3 (mean [SD], 17.4% [10.4%]) (P = .02) (Figure 2). However, there was no significant difference in the percentage of positively stained cells on either the epithelial or endothelial side between cytokeratin 19 and cytokeratin AE1/AE3 in epithelial downgrowth specimens (Figure 3).

Representative sections of staining on the endothelial side of control corneal and epithelial downgrowth specimens with MUC16, cytokeratin AE1/AE3, and cytokeratin 19 are shown in Figure 4.

**COMMENT**

Anti–cytokeratin AE1/AE3 identifies most acidic and basic cytokeratins of multiple molecular weights and has broad sensitivity for epithelial cells.6,12 The antibody is the most commonly used immunohistochemical stain for the identification of epithelial downgrowth.13,14 Previous studies promulgated that corneal epithelial cells were the only keratin-containing cells in normal cornea.13,15 However, later studies have demonstrated that the corneal endothelium does appear to express keratins. Weinreb and Ryder15 demonstrated general anticytokeratin staining of normal corneal endothelium using indirect immunofluorescence. These studies postulated that corneal endothelium might be morphologically similar to simple epithelial cells found in other tissues. Shamsuddin et al7 found that normal corneal endothelium lacked some of the ultrastructural characteristics of vascular endothelium using electron microscopy. They also
demonstrated immunohistochemical reactivity of the endothelium with a number of epithelial markers including general anticytokeratin and proposed that corneal endothelium may not be vascular endothelium. Further studies have found that specific cytokeratins, such as cytokeratin 7, 8, 18, and 19, are expressed in human corneal endothelial cells and that there are differences in the degree of expression of these cytokeratins even in normal corneal specimens. Cytokeratins, such as cytokeratin AE1, AE3, and 7, are also expressed in the endothelium of various ocular diseases, such as posterior polymorphous dystrophy, congenital hereditary endothelial dystrophy, iridocorneal endothelial syndrome, and Fuchs endothelial dystrophy. Our data indicate that keratoconus can be added to the list.

In this study, we found that while MUC16 and cytokeratin AE1/AE3 were both highly sensitive for detecting epithelial downgrowth, MUC16 was much more specific. Surprisingly, cytokeratin AE1/AE3 appeared to lack specificity; some degree of positive endothelial staining was observed in all control cases. Cytokeratin AE1/AE3 does in fact overlap with cytokeratin classes that are expressed in normal corneal endothelium. Cytokeratin 19 is a 40-kDa cytokeratin that reacts with anti–cytokeratin AE1 and cytokeratin 8 is a 52-kDa cytokeratin that reacts with anti–cytokeratin AE3.6,18 Therefore, cytokeratin AE1/AE3 may be a sensitive and robust immunohistochemical stain for detecting epithelial downgrowth; however, it may also lead to false-positive results. Our data did suggest that although the endothelium in the controls showed positive staining for cytokeratin AE1/AE3, there was a higher percentage of staining in the endothelium of epithelial downgrowth specimens. Therefore, a quantitative rather than a qualitative approach to interpretation of anti–cytokeratin AE1/AE3 in the assessment of epithelial downgrowth may mitigate false-positive interpretation.

Cytokeratin 19 has been touted as being specific for epithelial cells of conjunctival origin and has been used to study cicatricial conjunctivitis and limbal stem cell deficiency but, to our knowledge, had not yet been used to study epithelial downgrowth.23-25 The source of epithelial cells in epithelial downgrowth, conjunctival vs corneal epithelium, has been debated and both have been suggested as possible sources.2,13,26

In this study, cytokeratin 19 was applied in an attempt to differentiate whether the causative cells responsible for epithelial downgrowth arose from corneal or conjunctival epithelial cells. Cytokeratin 19 was previously reported to stain only conjunctival and not corneal epithelial cells.27 However, our data showed occasional expression in superficial and/or basal epithelial cells in control corneal specimens. Previous studies support our finding that cytokeratin 19 expression may not be limited to conjunctival epithelium.30,27 Our limited number of epithelial downgrowth cases all involved either complicated injuries or multiple operations, which may account for the variability in staining and does not clarify the source(s) of the epithelial cells. Cytokeratin 19 was also highly sensitive for epithelial downgrowth, but was less specific than MUC16.

The percentage of immunoreactive cells for MUC16, cytokeratin AE1/AE3, and cytokeratin 19 in control and epithelial downgrowth specimens did vary considerably, which was evident in the large standard deviations observed. An effort was made to minimize variability in staining by embedding all control and epithelial downgrowth specimens in 1 block. There may have been different levels of expression of MUC16, cytokeratin AE1/AE3, and cytokeratin 19 depending on the mechanism of disease or the number or types of previous surgeries. Another limitation of our study is the relatively small sample sizes. The results, however, were sufficient to identify clear qualitative and statistically significant differences between the immunohistochemical stains.

Epithelial downgrowth is a rare, yet serious complication of ocular surgery or trauma. MUC16 seems to be a sensitive and much more specific immunohistochemical stain compared with cytokeratin AE1/AE3 and may assist in the timely and definite diagnosis of epithelial downgrowth.

Submitted for Publication: February 13, 2010; final revision received March 6, 2010; accepted March 10, 2010.

Correspondence: Ben J. Glasgow, MD, Jules Stein Eye Institute, 100 Stein Plaza, UCLA, Los Angeles, CA 90095-7000 (bglasgow@mednet.ucla.edu).

Author Contributions: The authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Financial Disclosure: None reported.

Funding/Sponsor: This study was supported by National Institutes of Health grant EY11224 and by the Edith and Lew Wasserman Professorship.

REFERENCES


Unusual Findings After Vitrectomy

Thekla G. Papadaki, MD, PhD

Marco Mura, MD

Mirjam E. J. van Velthoven, MD, PhD

H. Stevie Tan, MD, PhD

Slitlamp biomicroscopy findings 1 day after 25-gauge pars plana vitrectomy for epiretinal membrane in a pseudophakic eye. Triamcinolone acetonide was given intravitreally at the end of the case. Note the triamcinolone crystals staining a vitreous tag attaching to the phacoemulsification incision.