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# Morphologic Classification of Filtering Blebs after Glaucoma Filtration Surgery: The Indiana Bleb Appearance Grading Scale

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**Purpose:** To establish a new classification system for filtering blebs according to clinical morphologic parameters. The purpose of this classification system is to provide a uniform and objective assessment of bleb appearance and establish a framework system through which outcomes of filtration surgery may be better correlated to clinical morphology.

**Materials and Methods:** The Indiana Bleb Appearance Grading Scale contains a set of photographic standards illustrating a range of filtering bleb morphology selected from the slide library of the Glaucoma Service at the Indiana University Department of Ophthalmology. These standards consist of slit lamp images for grading bleb height, extent, vascularity, and leakage with the Seidel test. For grading, the morphologic appearance of the filtration bleb is assessed relative to the standard images for the 4 parameters and scored accordingly. Fifty-one clinical bleb photographs were evaluated and scored by 3 glaucoma subspecialists in a masked fashion according to the scale.

**Results:** For all of the grading scales, high interobserver agreement was found using the scale to classify the appearance of filtering blebs (height +0.76; extent +0.78; vascularity +0.90, interclass correlation coefficient for consistency using a 2-way mixed effect model).

**Conclusion:** The Indiana Bleb Appearance Grading Scale is a simple, reproducible, yet comprehensive system for classifying the morphologic slit lamp appearance of filtration blebs.

**Key Words:** Bleb—Classification—Glaucoma—Morphology.

Since Cairns and Watson introduced trabeculectomy in 1968, the success of this procedure has hinged on the development of a functioning filtration bleb, which is in turn influenced by a number of factors including postoperative wound-healing properties.[1] Accurate assessment of the morphologic progression of the filtering bleb is critical in the short-term postoperative and longer-term follow-up period to assess potential signs of failure and the development of complications. Estimation of potential outcomes, the effects of various strategies to modulate wound healing, the need for further treatment, and the timetable for different medical and surgical interventions depends, in part, on the morphologic appearance of the filtration bleb and the intraocular pressure (IOP). While IOP is measured in a standardized fashion, a standardized system of evaluating bleb morphology has not been developed and accepted.

Although various classification systems of filtration blebs based on morphologic features have been presented as parts of other investigations, there has been considerable variability in the features of the filtering bleb appearance included in these systems and in the manner in which morphologic features are described. Through these systems, favorable and unfavorable characteristics of bleb development have been discerned, and

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when correlated to IOP, patterns associated with bleb failure have emerged.[2]

The Indiana Bleb Appearance Grading Scale (IBAGS) is an attempt to unify and expand upon previous classifications systems based on filtering bleb morphology and thereby to establish a simple standardized method of bleb grading. The goal of having a uniform classification system is to improve our ability to monitor bleb filtration function through a more objective and consistent assessment and to correlate predicted outcomes to bleb morphology. A uniform system of classification will also facilitate early recognition of failing blebs patterns, and thereby promote more timely aggressive intervention.

## MATERIALS AND METHODS

### Selection of IBAGS Standard Images

From the patient slide library of the Glaucoma Service at the Indiana University School of Medicine Department of Ophthalmology, we selected standard slit lamp images felt to be representative of a comprehensive range of bleb morphology. These standards consist of 4 images for grading bleb height (H), 4 images for grading bleb extent (E), 5 images for grading bleb vascularity (V), and images using topical fluorescein application viewed through cobalt-blue filter illumination for assessing leakage with the Seidel test (S). Each of the standard images within a specific parameter (height, extent, vascularity, and Seidel test) generally represents an equal scaling interval (H0–3, E0–3, V0–4, S0–2), serving as boundaries/cutoffs for classification (Fig. 1).

#### *Standards for Height*

Bleb height assesses the vertical dimension of the filtering bleb representing elevation of the conjunctival flap above the scleral surface and is divided into 4 scaling intervals serving as boundaries for classification: H0, flat bleb without visible elevation; H1, low bleb elevation; H2, moderate bleb elevation; and H3, high bleb as compared with the standard images.

#### *Standards for Extent*

Bleb extent represents the horizontal dimension of the filtering bleb, or bleb area, and is also divided into 4 scaling intervals based on clock hours serving as boundaries for classification: E0, no visible bleb extent to less than 1 clock hour; E1, extent equal to or greater than 1 clock hour but less than 2 clock hours; E2, extent equal to or greater than 2 clock hours but less than 4 clock hours; and E3, extent equal to or greater than 4 clock hours.

#### *Standards for Vascularity*

Bleb vascularity represents an assessment of the surface and deep vessel visibility upon slit lamp examination of the conjunctiva over the site of the filtration bleb and is divided into 5 scaling intervals serving as boundaries for classification: V0, avascular/white (no microcysts visible on slit lamp examination); V1, avascular/cystic (microcysts of the conjunctiva visible on slit lamp examination); V2, mild vascularity; V3, moderate vascularity; and V4, extensive vascularity (vascular engorgement). Although both V0 and V1 represent avascular blebs, the absence or presence of microcysts can be distinguished. In addition, the V1 bleb is relatively transparent, whereas the V0 is white and relatively opaque.

#### *Standards for Seidel test*

A positive Seidel test represents leakage of aqueous humor through the bleb surface. Application of fluorescein with a fluorescein strip to the filtration bleb, and examination through the cobalt-blue slit lamp filter is required. The Seidel test assessment is divided into 3 scaling intervals serving as boundaries of classification: S0, no bleb leak; S1, pinpoint transconjunctival leakage visible on the bleb surface (at multiple points), without streaming of fluid within 5 seconds of application; and S2, streaming aqueous egress visible within 5 seconds of application of fluorescein (diffuse or localized).

### Rules for Classification with the IBAGS System

For each of the 4 parameters of height, extent, vascularity, and Seidel testing, the grader decides in which interval the features of the filtration bleb falls and is scored accordingly.

To grade height (H0–H3), the score is assigned relative to the standard images of height and is based on the highest point from the scleral surface to the bleb. Classification of height is only possible with a narrow slit lamp beam used to enhance visibility. For assessment of extent (E0–E3), if the appearance of the filtration bleb falls on a standard between intervals, then the higher standard is used. For example, if the horizontal extent of a filtration bleb is precisely 2 clock hours, then the IBAGS grade will be E2. To grade vascularity (V0–V4), only blood vessels visible on the filtration bleb are used in assigning grade rather than any peribleb conjunctival injection. To grade the Seidel test (S0–S2), both S1 and

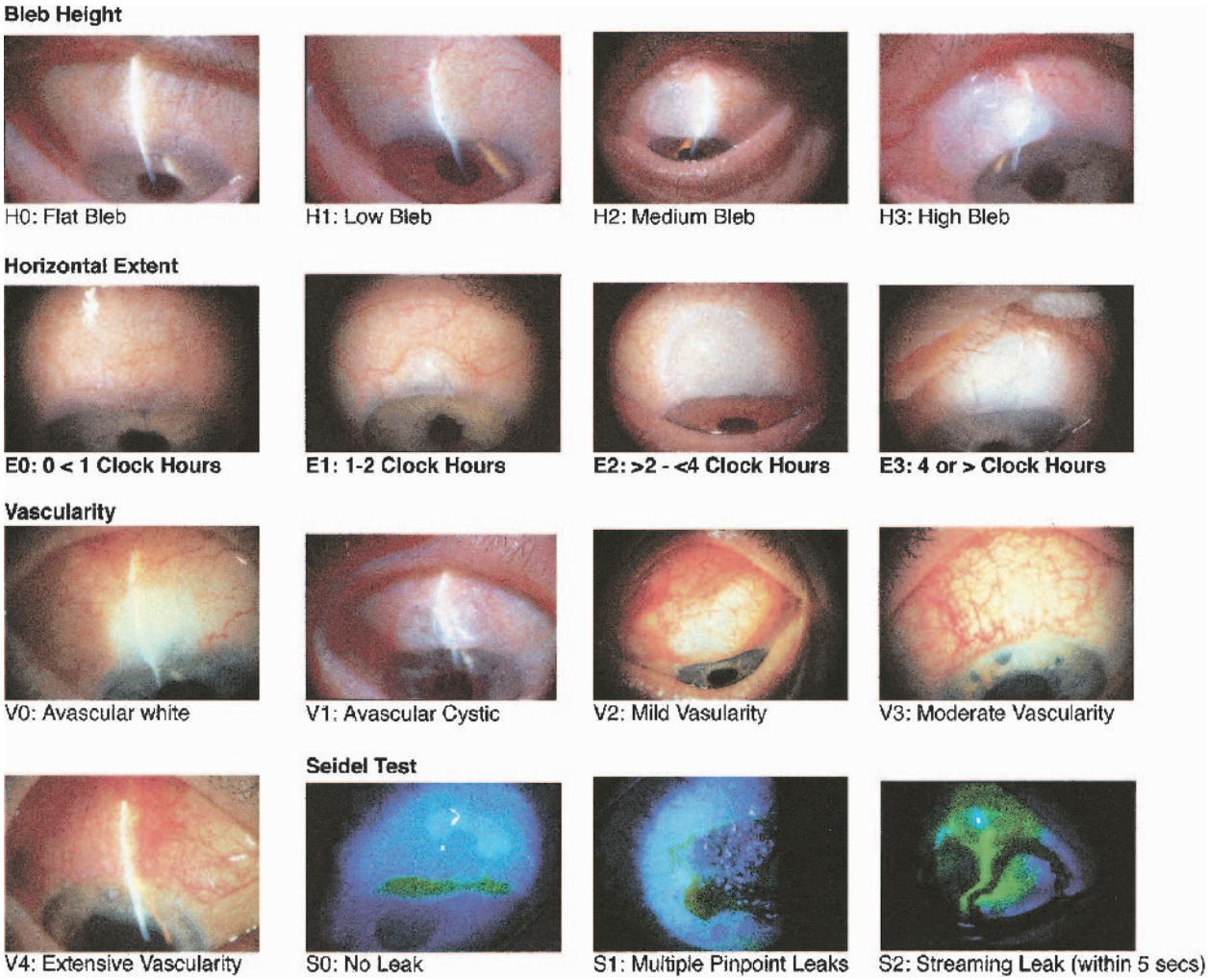


**FIG. 1.** Photographic standards of the Indiana Bleb Grading Scale for height (H0–H3), extent (E0–E3), vascularity (V0–V4), and leakage graded with the Seidel test (S0–S2).

S2 may represent either focal or diffuse aqueous egress. The distinction is that S1 represents punctate leakages on the bleb surface (multiple) without visible streaming of fluid within 5 seconds, whereas S2 represents streaming flow (either focal or diffuse) within 5 seconds of fluorescein application.

The Tenon cyst, or encapsulated bleb, is not distinctly named as a part of the IBAGS as it is already incorporated within the descriptive classification scheme. The cyst represents hypertrophied Tenon capsule confining aqueous with consequentially elevated IOP. The morphologic appearance of a Tenon cyst is highly elevated and "dome shaped," localized, without microcystic changes and variable vascularity.[2–4] Thus, according the IBAGS, the morphologic appearance of a Tenon cyst will typically fall within IBAGS score range of H2–H3, E1–E2, V3–V4, and S0.

## Evaluating the IBAGS System

In an attempt to ascertain reproducibility of the IBAGS, 51 photos of filtration blebs were selected from the patient slide library of the Glaucoma Service at the Indiana University School of Medicine Department of Ophthalmology. All the blebs were the result of a primary trabeculectomy with Mitomycin C or fluorouracil.

The slides were coded by a technician and arranged in random sequence. The 51 slides were independently viewed and scored using the IBAGS photographic standards by 3 of the authors (LBC, DW, AC). Seidel assessment reproducibility amongst the three graders was not assessed in this study as this is a dynamic measure that cannot be graded from photographs. Responses from the evaluators on grading height, extent, and vascularity were compared for agreement. Interclass correlation

coefficients using the 2-way mixed effect model for calculating consistency and absolute agreement were derived. Interobserver consistency and absolute agreement serves as a reflection of the clinical reliability demonstrating the degree to which different testers can achieve the same scores when assessing bleb morphology.

## RESULTS

The results from graders are presented in Table 1. Complete agreement among all 3 graders was achieved in the grading of 15 (29%) images for height, 23 (45%) images for extent, and 19 (37%) images for vascularity. Two-out-of-three agreement was obtained for all but 2 bleb photos for height, 2 photos for extent, and 3 photos for vascularity. Table 2 lists the interclass correlation coefficients for consistency and absolute agreement.

For all 3 parameters, complete concordance was achieved in the grading of 6 images, while 12 images received identical grades on 2 of the 3 parameters. There were 6 photos in which the level of agreement differed by 2 or more grades for any of the parameters.

For each of the 3 categories of classification, the consistency and absolute agreement was greater than +0.75 (height +0.76; extent +0.78; vascularity +0.90). Vascularity was more consistently graded, and had higher interobserver absolute agreement than either height or extent. However, it should be noted that for most of the clinical images, vascularity was graded as either V0, V1, or V2.

## DISCUSSION

The Indiana Bleb Appearance Grading Scale is a simple yet comprehensive classification system based on photographic standards incorporating the 4 major relevant features of bleb morphologic assessment: height, extent, vascularity, and Seidel test, and combining these into a single unified system. This system is introduced with the intention of creating a standardized, reproducible classification that translates an inevitably subjective evaluation into a more objective appraisal.

**TABLE 1.** *Results of photograding using IBAGS**

| | Height | Extent | Vascularity |
|---|---|---|---|
| Complete agreement | 15 | 23 | 19 |
| Grader A–B | 14 | 8 | 5 |
| Grader A–C | 12 | 7 | 15 |
| Grader B–C | 8 | 11 | 9 |
| No agreement | 2 | 2 | 3 |

**TABLE 2.** *Interobserver consistency and absolute agreement*

| | Consistency | Absolute agreement |
|---|---|---|
| Height | 0.76 | 0.75 |
| Extent | 0.78 | 0.77 |
| Vascularity | 0.90 | 0.86 |

Consistency and absolute agreement as calculated using 2-way mixed effect model.

### Previous Filtration Bleb Classification Systems and Morphologic Observations

In 1949, Kronfeld[5] proposed the first classification system of filtering blebs based on appearance and function into three categories (types I, II, and III). Kronfeld's type I bleb is a thin-walled, polycystic bleb with transconjunctival flow of fluid, and thus is a well-functioning bleb. The type II bleb is described as flatter, thicker, more diffuse and perilimbally extended, relatively avascular, and with good function. Kronfeld's type III bleb is a flattened bleb with little or no function, in which the scarred conjunctiva firmly adheres to the underlying sclera.[5–7] This initial scheme lacked description of the encapsulated bleb—the Tenon capsule cyst, which subsequently became an additional part of this classification system.[3]

Grehn et al.[8] used a subjective scale of grading vascularization of the blebs (none, moderate, severe) in a randomized prospective comparison of filtering blebs using a fornix-based versus limbus based conjunctival flap. Lederer,[9] in a retrospective analysis of patients receiving combined phacoemulsification with posterior chamber lens and mitomycin-augmented trabeculectomy, qualitatively compared bleb morphology of fornix-based versus limbus-based approaches. The filtering blebs achieved with the limbus-based conjunctival flap were usually avascular, highly elevated, translucent, thin walled, and cystic. In contrast, blebs with the fornix-based conjunctival flap were more vascular, moderately elevated, large in surface area (extending 3 or 4 clock hours at the limbus and extending far posteriorly), lacked well-demarcated margins, and were not cystic.

Vesti[10] retrospectively examined 88 eyes after trabeculectomy in an attempt to correlate biomicroscopic appearance and function of the filtering bleb with IOP and detect possible risk factors for bleb failure. Blebs were graded into 3 groups: diffuse filtering bleb with or without macroscopic cysts, flap sized bleb, and bleb failure. A clear association between a diffuse bleb and a good IOP response was observed.

In an attempt to correlate filtering bleb appearance to

function after trabeculectomy with Mitomycin C, Yamamoto et al.[6] used ultrasound biomicroscopic images to further elucidate intrableb structure and establish a new classification system for filtering blebs. Blebs were classified into 4 distinct groups: type L (low-reflective) blebs showed good IOP control, with moderate-high bleb height, and identifiable microcysts; type H (high-reflective), type F (flattened), and type E (encapsulated) were associated with poor IOP control, and both E and F types were generally discernable with slit lamp biomicroscopy alone. The presence of microcystic spaces visible by slit lamp examination corresponded to histologically clear spaces in the subepithelial connective tissue in a comparison of functioning and failed filtering blebs through light and electron microscopic examination.[7] Thus, the observation of microcystic spaces at the slit lamp is likely a good sign of bleb function potentially serving as channels for passage of aqueous humor.

Shingleton[11] noted morphologic characteristics of a successful filtering bleb and early signs of failure. A framework for categorizing failing filtration using IOP and bleb characteristics was established to help identify patterns of failure. In a retrospective study, Picht and Grehn[12] observed the appearance of the filtering bleb and the IOP for 3 months after trabeculectomy. The morphology of 53 developing filtering blebs were classified using the following parameters: 1) presence/absence of microcysts at 3 sectors of the filtering bleb; 2) quantity, shape, and diameter of conjunctival vessels compared with standard photographs (rated + to +++); 3) presence/absence of encapsulation if the filtering bleb; and 4) height of the filtering bleb compared with standard photographs (rated + to +++).

These previous investigations, all of which have included varied assessments of bleb morphology, emphasize a general consensus in the morphologic features that indicate favorable versus unfavorable filtering bleb development.

### The Indiana Bleb Appearance Grading Scale

Supported by previous morphologic observations,[1,4,11,12] height, extent, vascularity, and Seidel testing are the primary bleb features bearing the greatest clinical significance on outcome. Included in the vascularity grade is the assessment for the presence of microcysts, which has been shown to correspond histologically to patent channels for aqueous passage. To avoid redundancy, the Tenon cyst is not separately named as a part of the IBAGS as it is covered in the descriptive grading of the IBAGS system.

Prior evaluations of morphology correlated to outcomes point to favorable features of filtering blebs, including moderate elevation, diffuse extent, and scarcity of vascularity with conjunctival microcysts (K. Swamynathan, A. Cortes, D. WuDunn D, et al., unpublished data recorded/presented June 2001).[1,4] This would correspond to IBAGS score range of H1–2, E1–3, V1, S0. However, flatter, more diffuse, avascular white blebs may also successfully lower IOP.[4]

The clinical utility of IBAGS has been strengthened with excellent consistency and interobserver agreement in assessment of height, extent, and vascularity. It is not easy to completely correct for variability in grading among observers within a system that relies on clinical judgment and inherent subjectivity. Through the use of photographic-derived standards, however, the sources of measurement error encountered while classifying filtering bleb morphology are minimized[13] relative to a system in which standards are simply defined. Attempts to validate other similar systems of grading, most notably the Lens Opacities Classification System (LOCS III),[13] have used the standard deviation of the discrepancy distribution as a measure of the reproducibility of grading among 2 observers.

Use of a coherent, standardized system of classification may facilitate detection of early failure, better prediction of outcomes and monitoring response to intervention. For example, a H1E1V2S0 bleb in the setting of a high IOP, may point to external subconjunctival fibrosis as the etiology of filtration failure.[2] Management may entail digital pressure with concomitant use of topical corticosteroids. A measured response to intervention reflected by a grade of H2E2V2S0 may be evident on follow-up, which would be relevant in directing further intervention. Clearly the subjective nature of bleb assessment can now be translated into a calculated clinical improvement.

The clinical application of the IBAGS will be useful to uniformly assess and communicate morphologic features of both limbus-based and fornix-based filtration blebs. Standardized classification of filtering bleb morphology with the IBAGS is a more measured approach to monitoring bleb progression, detecting early filtration failure, and evaluating response to intervention, and sets the stage for more objective correlations between morphologic appearance and outcomes.

## REFERENCES

1. Picht G, Grehn F. Classification of filtering blebs in trabeculectomy: biomicroscopy and functionality. *Curr Opin Ophthalmol.* 1998, 9;II:2–8.
2. Shingleton BJ. Management of the failing glaucoma filter. *Surg Rev.* 1996;27:445–51.

3. Van Buskirk EM. Cysts of Tenon's capsule after filtration surgery. *Am J Ophthalmol.* 1982;94:522.
4. Skuta G, Parrish R. Wound healing in glaucoma filtering surgery. *Surv Ophthalmol.* 1987;32:149–170.
5. Kronfeld PC. The mechanisms of filtering operations. *Trans Pac Coast Otoophthalmol Soc Annu Meet.* 1949;33:23–40.
6. Yamamoto T, Sakuma T, Kitazawa Y. An ultrasound biomicroscopic study of filtering blebs after Mitomycin C trabeculectomy. *Ophthalmology.* 1995;102:1770–1776.
7. Addicks EM, Quigley HA, Green E, et al. Histologic characteristics of filtering blebs in glaucomatous eyes. *Arch Ophthalmol.* 1983;101:795–798.
8. Grehn F, Mauthe S, Pfeiffer N. Limbus-based versus fornix-based conjunctival flap in filtering surgery. *Int Ophthalmol.* 1989;13: 139–143.
9. Lederer CM. Combined cataract extraction with intraocular lens implant and mitomycin-augmented trabeculectomy. *Ophthalmology.* 1996;103:1025–1034.
10. Vesti E. Filtering blebs: follow-up of trabeculectomy. *Ophthalmic Surg Lasers.* 1993;24:249–255.
11. Shingleton B. Management of the failing glaucoma filter. *Ophthalmic Surg Lasers.* 1996;27:445–451.
12. Picht G, Grehn F. Classification of filtering blebs: a correlation to outcome 3 months after trabeculectomy [ARVO abstract]. *Invest Ophthalmol Vis Sci.* 1997;38:1060.
13. Chylack L, Wolfe J, Singer D, et al. The lens opacities classification system III. *Arch Ophthalmol.* 1993;111:831–836.