Silicon-Hydrogel Combination (“Piggy-back”) Contact Lens Systems:
Does the Blink Alter Their Effective Oxygenation of the Epithelial Surface ?

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Introduction

Current Combination (“piggy-back”) System Questions:

1. How does the transmissibility of the carrier lens [e.g., of silicon-hydrogel (SH) vs. other soft lens materials] affect post-lens epithelial oxygenation?
2. How do cap lenses of different transmissibilities, but on the same carrier lens, affect post-lens epithelial oxygenation?
3. Does the blink alter the epithelium oxygenation response? Is its relative effectivity related to the cumulative transmissibility of the system?[1-6]

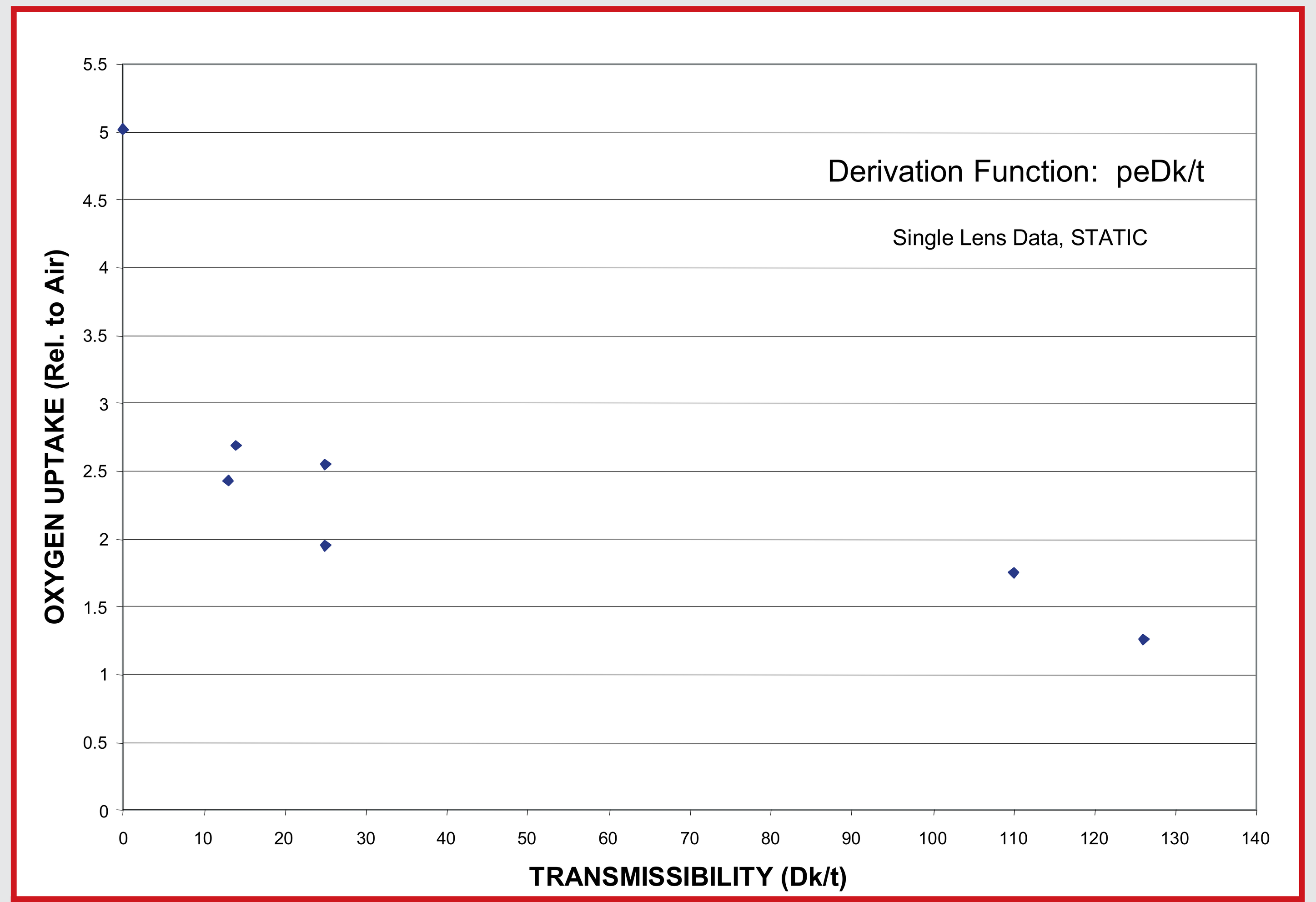
Methods

Methods

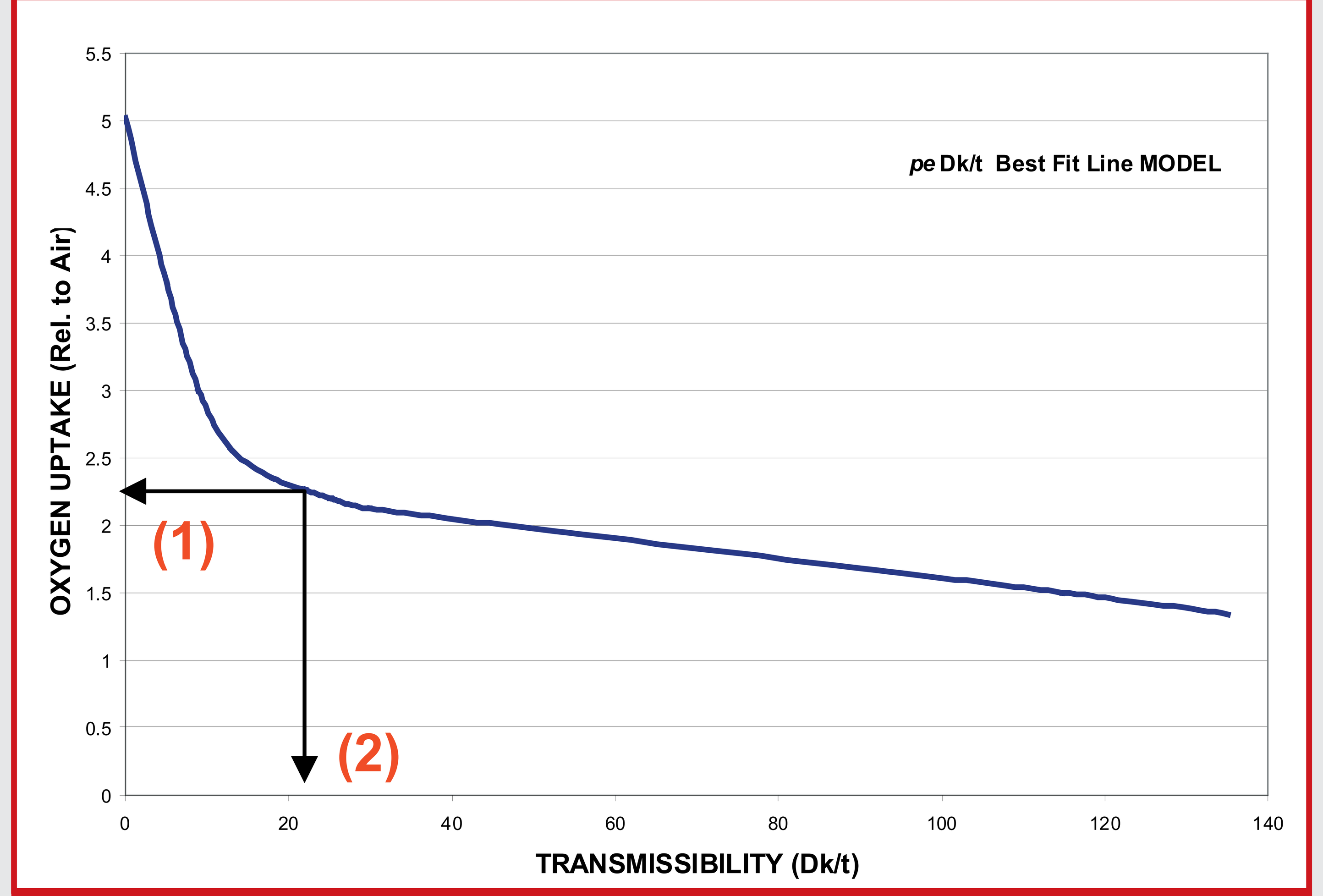
Eyes	The right corneas of 10 subjects (5 male; 5 female), of average age 25 years (range 22 to 30), all being non-contact lens wearers with normal ocular health.
Testing	Polarographic measurements were made at the central corneal surface.[3]
Materials*	Fluoroperm 30 (FL30): Dk = 30 x 10-11; t = 0.12 mm; Dk/t = 25 x 10^{-9}. (cap) Fluoroperm 151(FL151): Dk = 151 x 10-11; t = 0.60 mm; Dk/t = 25 x 10^{-9}. (cap) Fluoroperm 151(FL151): Dk = 151 x 10-11; t = 0.12 mm; Dk/t 126 x 10^{-9}. (cap) PureVision: Dk = 99 x 10-11; t = 0.09 mm; Dk/t = 110 x 10^{-9}. (insert) Permalens: Dk = 34 x 10-11; t = 0.26 mm; Dk/t = 13 x 10^{-9}. (insert) Optima 38: Dk = 8.4 x 10-11; t = 0.06 mm; Dk/t = 14 x 10^{-9}. (insert) PMMA: Dk = 0 x 10-11; t = 0.12 mm; Dk/t = 0 x 10^{-9}. (control) *All GP (CAP) lenses were 8.80 mm OAD, and were fitted to the flattest K when used alone, and 0.2 mm flatter than K when used in combination.
Procedures	Each cornea was measured one time and averaged with the others for responses to each of the following conditions/combinations (immediately after 5 min. rest intervals between measurement trials): A. No-lens (air) B. PMMA alone C. FL30 D. FL151(.12) E. FL151(.60) F. PureVision (PV) G. Cooper (CP) H. Opt38 I. PV + FL30 J. PV + FL151(.60) K. PV + FL151(.12) L. CP + FL30 M. CP + FL151(.60) N. CP + FL151(.12) O. Opt38 + FL30 P. Opt38 + FL151(.60) Q. Opt38 + FL151(.12) Two trial series were done: (1) statically (i.e., with blink suspended) to avoid oxygen access by bulk flow (lid driven tear exchange under the lens), and (2) dynamically (i.e., with an ongoing blink rate of 12/min).[4,5]
Statistical Analyses	All rates of oxygen uptake for lens conditions for a particular eye were ratioed to the no-lens (air) rate for that eye. Repeated measures analysis of variance was used to test for significant differences among the pre-Dk/t conversion rates for each condition, and Tukey’s test was used for post-hoc comparisons. Given the large number of post-hoc pairwise comparisons, the alpha level for significance was set at 0.01.

Derivation Function for peDk/t Values:

The points in A. are the average single lens empirical ratesmeasured for each lens type in this study.



A. Single Lens Mean Data

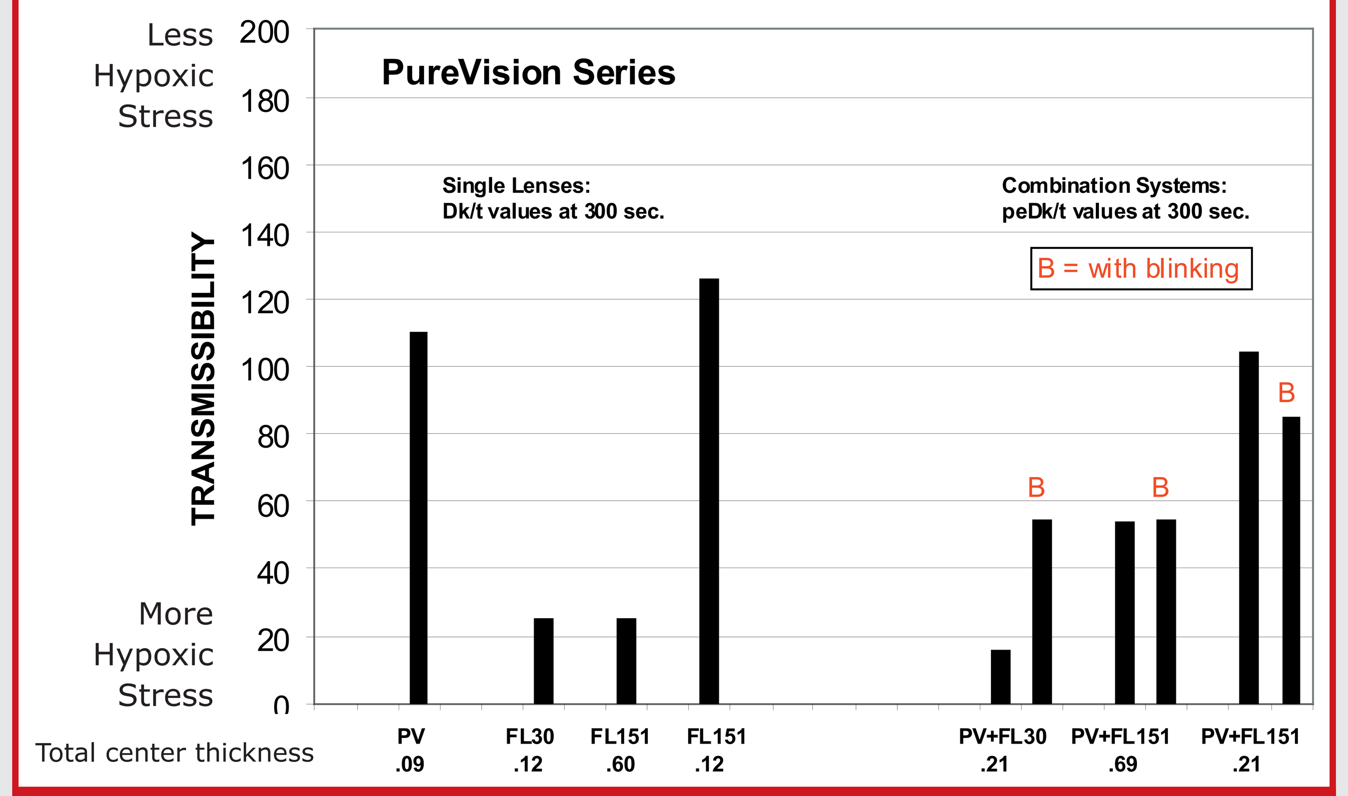


B. Fitted Model

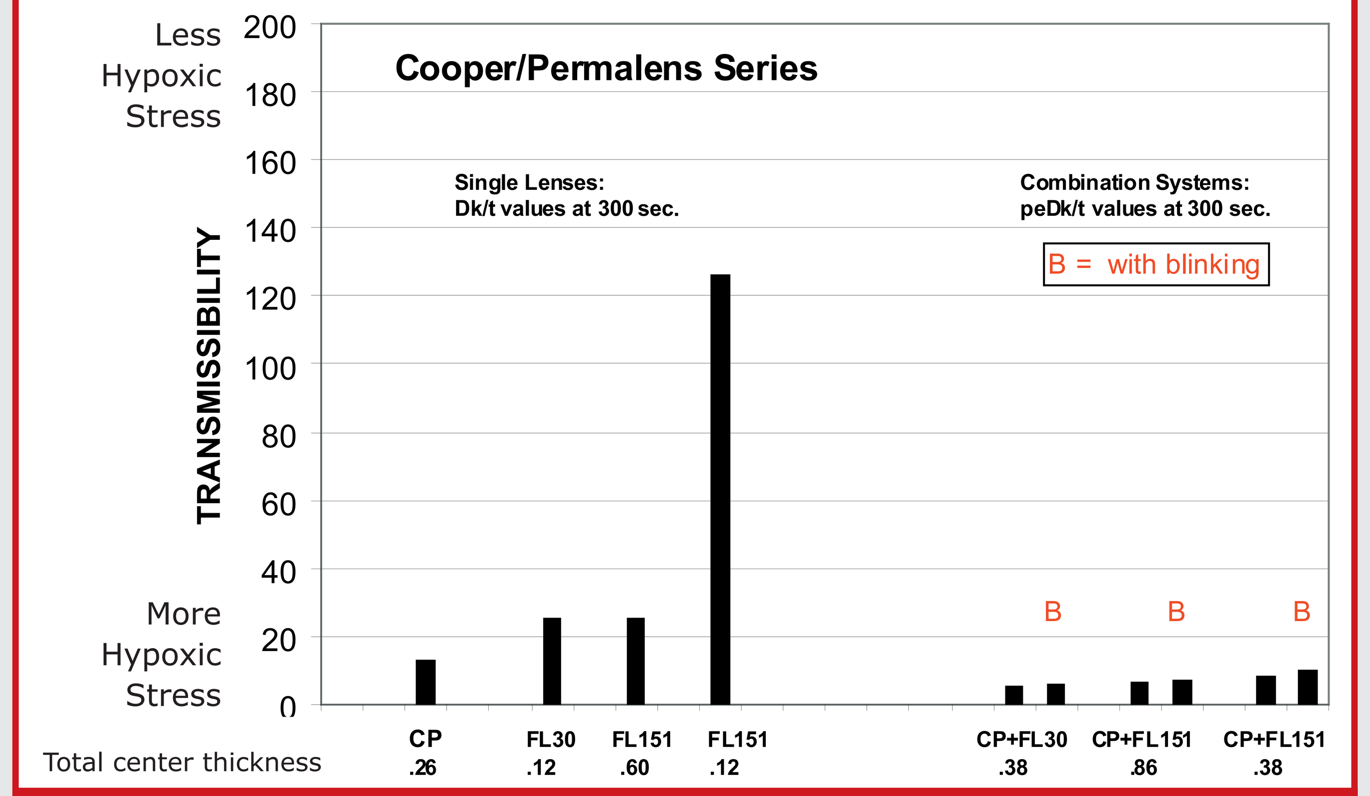
To estimate the physiologically equivalent transmissibility, peDk/t, of a combination system from the Fitted Model (B.):

1. enter the measured uptake rate for the system on axis y; then,
2. read the matching transmissibility value (the pe Dk/t) on axis x.

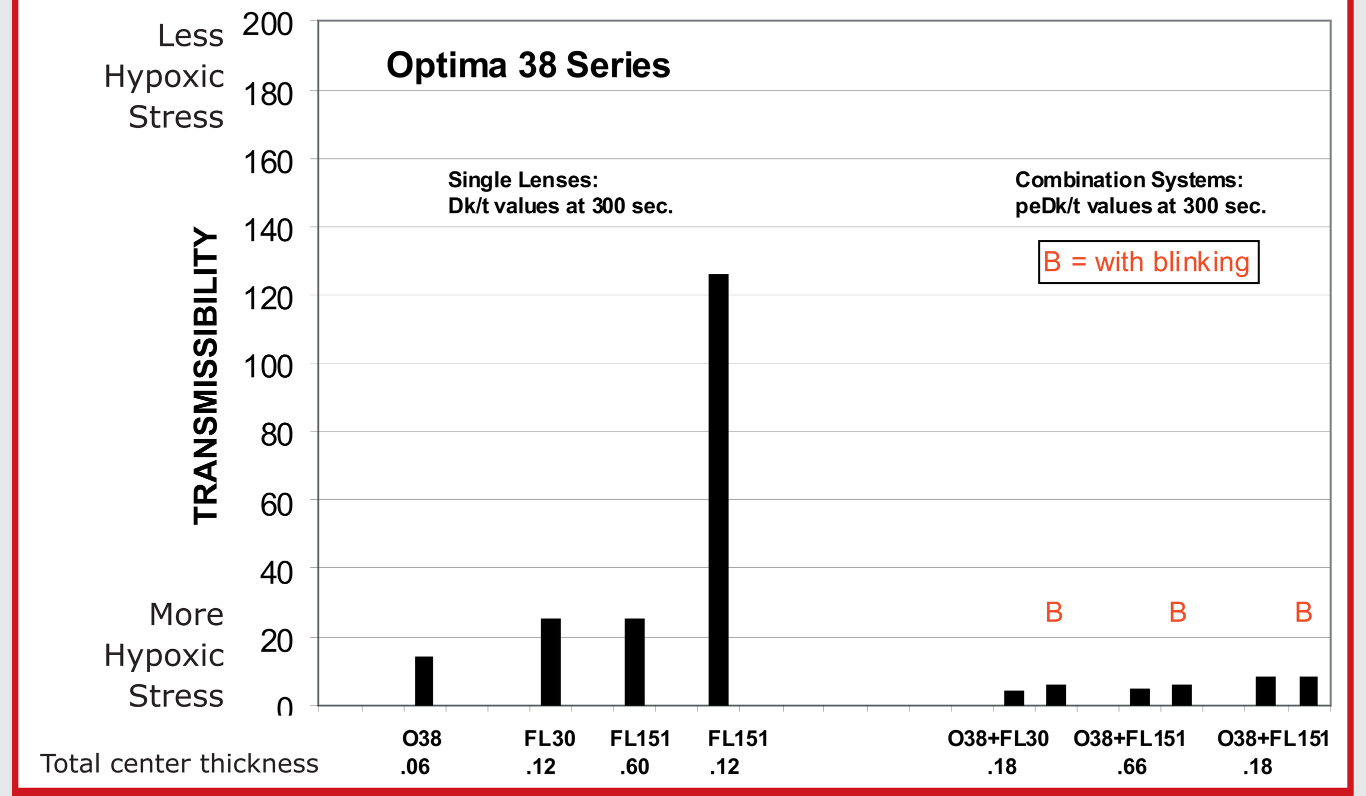
Results



A. peDk/t Values for the PureVision Series



B. peDk/t Values for the Cooper/Permalens Series



C. peDk/t Values for the Optima Series

Observations/Conclusions

1. Differences in physiological response (due to corneal surface oxygenation) between static (no blink) and dynamic (blink) were best seen among the cases within the highest Dk carrier lens (PureVision) series; wherein:
   (a) the lowest Dk (FL30) cap + carrier case benefited most from presence of the blink;
   (b) the thicker, high Dk cap lens (FL151 .60) + carrier case showed no difference between non-blink and blink conditions; and
   (c) the highest Dk (FL151 .12) cap + carrier case showed an actual decrease in epithelial oxygenation with the blink vs. without [although both resulted in levels higher than any seen in either (a) or (b)].
2. Oxygenation outcomes between cases 1(a) and 1(b) appear due to their thickness differences (0.21 vs. 0.69 mm), as the calculated transmissibility value for both cases is identical (Dk/t = 25, + carrier), i.e., the combination moduli appear to strongly favor tear exchange in the FL30 cap lens case vs. the FL151.60 cap lens case.
3. Oxygenation outcomes between cases 1(b) and 1(c) may be due to their thickness differences as well (0.69 vs. 0.21 mm), but also to their differences in transmissibility (Dk/t’s = 25 vs. 110, + carrier). The very flexible modulus of the 1(c) combination may have resulted in “binding” and reduced tear exchange with the blink.
4. The remaining (Cooper and Optima) vehicle series showed no measurable differences between blink and non-blink outcomes (all were very low), and in none of the nine cases described were differences between blink and non-blink outcomes found to be statistically significant (p-range for all 9 cases = 0.263 to 0.924, as determined on the air ratioed uptake rate data).

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Disclaimer:

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