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User Group for Laser Interference Biometry

The keratometer index problem

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Now and then, there are reports on different K readings on the IOLMaster as compared to other keratometers. Also, discrepancies in IOL powers are reported comparing IOLMaster results with those obtained on ultrasound equipment even if the same input data was used. Very often, the described problems can be traced down to keratometer indices and/or to peculiarities of corneal power implementations in the IOL formulas of the respective instruments.

The following article is intended to help clarify this situation.

Keratometer indices

A keratometer does not measure corneal power, just as an A-scan does not measure distances. The respective primary measurement parameters are 'radius of curvature' (approximation to a best fit sphere) and 'time of flight'. We, on the other hand, are interested in corneal power in [D] and e.g. axial length in [mm]; so conversion factors are needed. In keratometry, conversion is provided by a suitable keratometer index, in echobiometry by the respective velocity of sound.
In the United States, the keratometer index used for conversion of radius to power is 1.3375. However, there are instruments on the market using an index different from 1.3375, e.g. *American Optical, Haag-Streit*: 1.336; *Zeiss, Gambs, Topcon*: 1.332; *Hoya*: 1.338. While a given patient should produce the same radii on all these instruments, his Ks will definitely be different, of the order of up to 0.8 D.

(To appreciate the influence of different keratometer indices, you may want to go to http://www.augenklinik.uni-wuerzburg.de/service/hhcalce.htm and perform some online calculations with different indices and radii.)

Which kind of Ks do IOL formulas expect ?

From the above it is clear that IOL formulas will produce different lens powers depending on the different Ks entered. Which IOL power, then, is the correct one ? The one calculated with Ks from the *American Optical* instrument ? Or the *Hoya* ? Or another one ? We'll try to anwer this question below.
In some of their internal algorithms, IOL formulas are characterized by the clinical experience of their authors. This is where the empirical expressions come from in the individual formulas. Clinical experience is strongly influenced by the measurement equipment, like, for example, by keratometers with an index of 1.3375.
For optimum formula performance it is essential that a patient out in the field produces the same Ks as if he were measured in the formula author's office with the instrument that ultimately delivered the empirical basis of his formula. This has – in the United States - most likely been an instrument with an index of 1.3375. In fact, all of the current IOL formulas with the exception of the the *Haigis* formula implicitly assume that Ks originate from an instrument using 1.3375 (cf Fig.1).

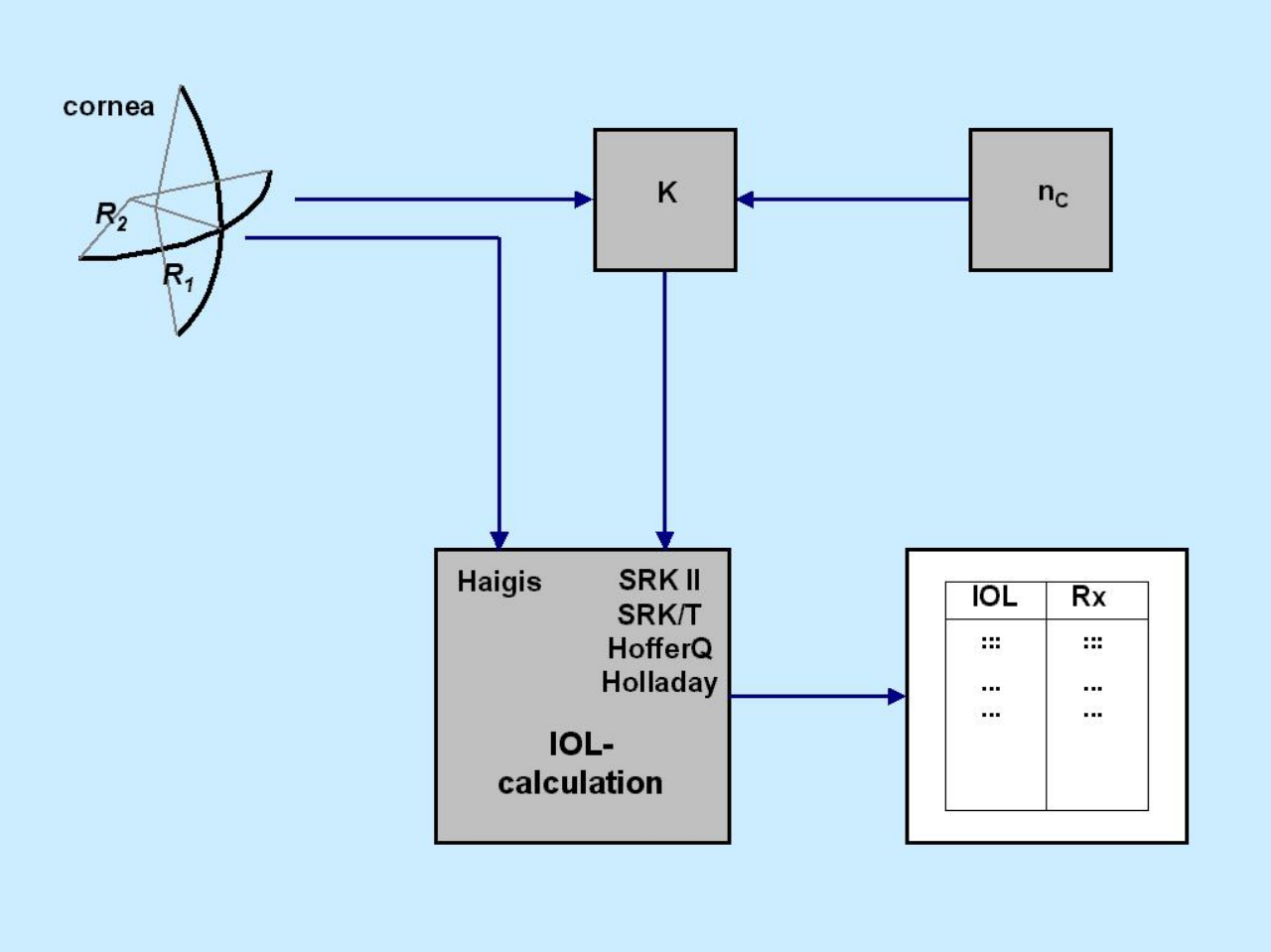

Fig.1: Keratometers measure radii – all IOL formulas but the *Haigis*, however, expect Ks from an instrument with a keratometer index of 1.3375.

The basic point in K transformation is that while formula *authors* have their own ways of calculating corneal power from measured radii R i.e. for the translation **R » K**, the derivation of radii from measured Ks - i.e. **K » R** - solely depends on the keratometer index used by the *instrument*.

IOL formulas may be miscredited by 'wrong' Ks

If, for example, patients would have perfect results with data from a 1.3375 keratometer, they would be off by some 0.8 D when measured on a 1.332 instrument. In the latter case, it would not be fair to say 'the formula is bad'. This statement would be wrong, because the formula actually is good but the input data was definitely bad.
To prevent this from happening, it is reasonable to go back to the actually measured parameters - namely radii of curvature - because they should be identical irrespective of the instrument used. Once radii are obtained, they can be re-converted into Ks again, this time using 1.3375. Thus, the formulas get what they want (namely Ks from 1.3375 sources) and can process these Ks in whichever way they want.

So, to prevent IOL formulas from being miscredited by wrong input data in a world where there is more than one keratometer index, a 2-stage procedure seems reasonable:
1. start out from radii of curvature or convert back from Ks to radii making allowance for the calibration of the source instrument,
2. use the keratometer index (1.3375) which the IOL formula expects to have been used during keratometry.

How the IOLMaster handles the K problem

The IOLMaster makes use of the above approach. The index of the keratometry source has to be input under *'options-setup-program-keratometer-refractive index'* (user manual, page 20; cf Fig.2). In IOLMaster instruments for the US market, the default setting is 1.3375. For other countries, the factory-set value is 1.332.

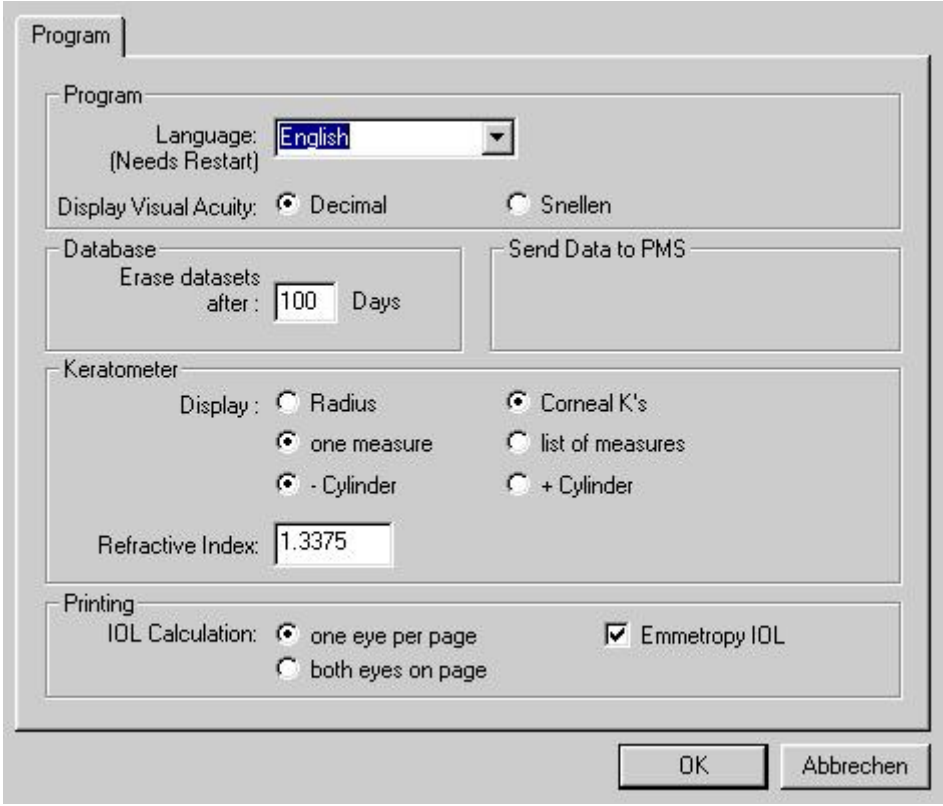

Fig.2: If, in the IOLMaster, Ks are manually entered in diopters, the refractive index set here (under *'options-setup-program-keratometer-refractive index'*) is used to convert Ks into radii. Each IOL formula in the IOLMaster by itself makes sure internally that the correct conversion is subsequently applied for power calculations. This setting, however, is only relevant if K readings are manually entered in diopters. In case the IOLMaster keratometry is used for IOL calculation, no problems occur.

Problems can only show up if
1. Ks are manually entered in diopters, and, at the same time,
2. the index under *'options-setup-program-keratometer-refractive index'* has not been choosen properly i.e. according to the index the external keratometer actually uses.

To further illustrate the situation: problems will e.g. occur in the following cases:
- if a German surgeon has **not** changed the default index setting (1.332) and enters Ks e.g. from a *Javal* type keratometer (index=1.3375)
- if an American surgeon has **not** changed the default index setting (1.3375) and enters Ks e.g. from a *Gambs* keratometer (index=1.332)
- if someone has fiddled around with the index setting and Ks are entered in diopters
- if Ks are entered from different K sources when no allowance is made for the individual K source indices.

No problems will arise
- if the German has **not** changed the default index setting (1.332) and enters Ks from a keratometer with an index of 1.332, or
- if the American has **not** changed the default index setting (1.3375) and enters Ks from a keratometer with an index of 1.3375, or
- the IOLMaster keratometry is used, i.e. no Ks are entered manually.

How do ultrasound systems handle the K problem ?

Ultrasound devices mostly do not distinguish between different 'K modes' but usually assume an index of 1.3375 to hold.
To check out the effect of different K sources you may **deliberately** produce an approximate 0.8 D difference relative to an ultrasound device by proceeding as follows:
1. set the index to 1.332 under *'options-setup-program-keratometer-refractive index'* in your IOLMaster,
2. enter Ks manually in diopters,
3. compare results on the IOLMaster and the A-scan.

Therefore, for comparison purposes with most A-scan equipment in the United States, 1.3375 must be set (or verified)in the IOLMaster's setup menu. In fact, as has already been mentioned, this is the default setting for the US whereas 1.332 is e.g. used in Germany.

After these checks, do not forget to reset the correct index in your IOLMaster !

Which formula, which equipment is affected by the K problem ?

The described problem will affect all biometry devices, all IOL formulas, and, likewise, all computer programs for IOL calculations if Ks are entered in diopters.
If whoever enters Ks originating e.g. from a *Haag-Streit* keratometer (1.336) into *any* K-accepting IOL program - running in the IOLMaster, in any A-scan, on any computer - he will stand a good chance to receive different IOL power than when he had measured the patient with a *Javal* type instrument (1.3375). In the IOLMaster, however, this problem can be overcome as has been discussed in the foregoing.

The difficulties described reflect a basic problem between primary and secondary measurement parameters and certainly contribute to reasons confusing comparisons of IOL formula performance.