Calculated oxygen transmissibility through various piggyback contact lens systems

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Purpose

To calculate values of oxygen transmissibility of piggyback (PB) systems by applying the concept of resistors in series,[1] and to create a color-coded spreadsheet to help the practitioner to choose a combination of soft and rigid lenses that provides enough oxygen to the cornea.

Method

Theoretical calculations were used to predict the oxygen transmissibility of PB systems, considering all FDA materials, for both soft and rigid gas permeable (RGP) lenses.[2] Different lens powers were taken into account.[3] The Holden-Mertz (HM) Dk/t criterion of 24 Fatt units[4] and the Harvitt-Bonanno (HB) criterion of 35 Fatt units[5] were used as reference points. The harmonic average thickness[6] was used when calculating oxygen transmission through the two lenses of the PB system. The oxygen transmission of a piggyback system was calculated using Ohm's law. The resistance of the two lenses in series was calculated as the sum of the resistance offered by each. Transmissibility is the reciprocal of resistance.

	Tefilcon	Polymacon	Deltafilcon A	Helfilcon A&B	Hioxifilcon B	Ocufilcon A	Focofilcon A	Ocufilcon B	Phemfilcon A	Vilfilcon A	Methafilcon A	Methafilcon B	Ocufilcon D	Hioxifilcon D	Hilafilcon B	Ocufilcon E	Acofilcon A	Nelfilcon A	Hioxifilcon A	Etafilcon A	Alfafilcon A	Omafilcon A	Nesofilcon A	Efrofilcon A	Somofilcon A	Narafilcon A	Enfilcon A	Senofilcon A	Senofilcon C	Lotrafilcon B	Balafilcon A	Samfilcon A	Comfilcon A	Lotrafilcon A	Delefilcon A	Elastofilcon
Dk	9	9	10	12	15	15	16	16	16	16	18	18	20	21	22	22	26	26	28	28	32	33	42	60	60	100	100	103	103	110	112	114	128	140	140	340
Boston II	12	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6
OP-2	15	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Paraperm O2	16	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	8	8	8	8
Boston ES	18	5	5	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9
Optacryl 60	18	5	5	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9
SA 18	18	5	5	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9
Boston IV	19	5	5	6	6	7	7	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9	9	9	9	9	9
Paragon HDS HI 1.54	22	6	6	6	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	9	9	9	9	9	10	10	10	10	10	10	10	10	10	10	10	11
SGP	22	6	6	6	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	9	9	9	9	9	10	10	10	10	10	10	10	10	10	10	10	11
Optimum Classic	26	6	6	7	7	8	8	8	8	8	8	9	9	9	9	9	9	10	10	10	10	10	10	11	11	11	12	12	12	12	12	12	12	12	12	13
Optimum HR 1.53	26	6	6	7	7	8	8	8	8	8	8	9	9	9	9	9	9	10	10	10	10	10	10	11	11	11	12	12	12	12	12	12	12	12	12	13
Flosi	26	6	6	7	7	8	8	8	8	8	8	9	9	9	9	9	9	10	10	10	10	10	10	11	11	11	12	12	12	12	12	12	12	12	12	13
Paragon Thin	29	7	7	7	8	9	9	9	9	9	9	9	9	10	10	10	10	10	10	11	11	11	11	12	12	12	13	13	13	13	13	13	13	13	14	14
Fluorex 300	30	7	7	7	8	9	9	9	9	9	9	9	9	10	10	10	10	11	11	11	11	11	11	12	13	13	14	14	14	14	14	14	14	14	14	15
Fluoroperm 30	30	7	7	7	8	9	9	9	9	9	9	9	9	10	10	10	10	11	11	11	11	11	11	12	13	13	14	14	14	14	14	14	14	14	14	15
OP-3	30	7	7	7	8	9	9	9	9	9	9	9	9	10	10	10	10	11	11	11	11	11	11	12	13	13	14	14	14	14	14	14	14	14	14	15
Hybrid FS	31	7	7	7	8	9	9	9	9	9	9	10	10	10	10	10	10	11	11	11	11	12	12	12	13	13	14	14	14	14	14	14	14	14	14	15
SA 32	32	7	7	8	8	9	9	9	9	9	9	10	10	10	10	11	11	11	11	11	11	12	12	13	13	13	14	14	14	14	15	15	15	15	15	15
SGP II	44	8	8	9	10	11	11	11	11	11	11	12	12	12	13	13	13	14	14	14	14	15	15	16	17	17	19	19	19	19	19	19	19	19	20	20	21
SGP 3	44	8	8	9	10	11	11	11	11	11	11	12	12	12	13	13	13	14	14	14	14	15	15	16	17	17	19	19	19	19	19	19	19	19	20	20	21
Boston Equalens	47	8	8	9	10	11	11	12	12	12	12	12	12	13	13	13	13	14	14	15	15	16	16	17	18	18	20	20	20	20	20	20	21	21	21	21	22
Fluorex 500	50	8	8	9	10	12	12	12	12	12	12	13	13	13	14	14	14	15	15	15	15	16	16	18	19	19	21	21	21	21	22	22	22	22	22	22	24
Optimum HR 1.51	50	8	8	9	10	12	12	12	12	12	12	13	13	13	14	14	14	15	15	15	15	16	16	18	19	19	21	21	21	21	22	22	22	22	22	22	24
Paraperm EW	56	9	9	9	11	12	12	13	13	13	13	13	13	14	14	15	15	16	16	16	16	17	18	19	21	21	23	23	24	24	24	24	24	24	25	25	26
ONSI-56	56	9	9	9	11	12	12	13	13	13	13	13	13	14	14	15	15	16	16	16	16	17	18	19	21	21	23	23	24	24	24	24	24	24	25	25	26
Boston EO	58	9	9	10	11	12	12	13	13	13	13	14	14	14	15	15	15	16	16	17	17	18	18	20	22	22	24	24	24	24	24	25	25	25	25	25	27
Paragon HDS	58	9	9	10	11	12	12	13	13	13	13	14	14	14	15	15	15	16	16	17	17	18	18	20	22	22	24	24	24	24	24	25	25	25	25	25	27
Paragon HDS non-UV	58	9	9	10	11	12	12	13	13	13	13	14	14	14	15	15	15	16	16	17	17	18	18	20	22	22	24	24	24	24	24	25	25	25	25	25	27
Fluoroperm 60	60	9	9	10	11	13	13	13	13	13	13	14	14	15	15	15	15	16	17	17	17	18	18	20	22	22	25	25	25	25	25	25	25	26	26	26	28
OP-6	60	9	9	10	11	13	13	13	13	13	13	14	14	15	15	15	15	16	17	17	17	18	18	20	22	22	25	25	25	25	25	25	25	26	26	26	28
Optimum Comfort	65	9	9	10	11	13	13	13	13	13	13	14	14	15	16	16	16	17	17	18	18	19	19	21	24	24	26	26	27	27	27	27	27	28	28	28	30
Fluorex 700	70	9	9	10	12	13	13	14	14	14	14	15	15	16	16	17	17	18	18	19	19	20	20	22	25	25	28	28	28	28	29	29	29	29	30	30	33
Boston Equalens II	85	10	10	11	12	14	14	15	15	15	15	16	16	17	18	18	18	20	20	21	21	22	22	25	28	28	33	33	33	33	33	34	34	34	35	35	39
Fluoroperm 92	92	10	10	11	12	15	15	15	15	15	15	16	16	17	18	19	19	20	21	21	21	23	23	26	30	30	35	35	35	35	36	36	36	37	37	37	42
Tyro-97	97	10	10	11	13	15	15	16	16	16	16	17	17	18	19	19	19	21	21	22	22	24	24	27	31	31	36	36	36	36	37	37	37	38	39	39	44
Boston XO	100	10	10	11	13	15	15	16	16	16	16	17	17	18	19	19	19	21	21	22	22	24	24	27	32	32	37	37	37	37	38	38	38	39	40	40	45
Paragon HDS 100	100	10	10	11	13	15	15	16	16	16	16	17	17	18	19	19	19	21	21	22	22	24	24	27	32	32	37	37	37	37	38	38	38	39	40	40	45
Optimum Extra	100	10	10	11	13	15	15	16	16	16	16	17	17	18	19	19	19	21	21	22	22	24	24	27	32	32	37	37	37	37	38	38	38	39	40	40	45
Optimum Extreme	125	11	11	12	13	16	16	17	17	17	17	18	18	19	20	21	21	23	23	24	24	26	27	31	36	36	43	43	44	44	45	45	45	47	48	48	55
Boston XO2	141	11	11	12	14	16	16	17	17	17	17	19	19	20	21	22	22	24	24	26	26	28	28	32	39	39	47	47	48	48	49	49	49	51	52	52	62
Fluoroperm 151	151	11	11	12	14	17	17	18	18	18	18	19	19	21	21	22	22	25	25	26	26	28	29	33	40	40	49	49	50	50	51	51	52	53	55	55	65
Menicon Z	163	11	11	12	14	17	17	18	18	18	18	20	20	21	22	23	23	25	26	27	27	29	30	35	42	42	52	52	52	52	54	54	54	56	58	58	70

Results

The combinations of 42 RGP and 36 soft materials were used for calculation, using a computer software spreadsheet. A summary table was created and a colour code was introduced to easily show if the PB system satisfies both HB and HM criteria (green), only HM criterion (yellow), or neither of them (red). This table represents the Dk/t of a PB system where the harmonic average thickness is 0.09 mm for the soft lens (valid for lenses ranging from −0.75 to +3.00 D, with an error <5%), and 0.20 mm for the RGP lens. As we can see, several combinations are available that can ensure an appropriate level of security in PB fitting. Nevertheless, hydrogel soft contact lenses should be used only if their Dk is greater than 25 units and they are combined with hyper-gas permeable RGP lenses (Dk>140). If the RGP lens Dk is 100, only hydrogel materials with Dk>30 should be used. Silicone-hydrogel soft contact lenses offer a larger choice of combinations, but the Dk of the RGP lens should not be less than 56 units. Different tables can be calculated varying the thickness and the power of both RGP and soft contact lenses. A free Excel calculator is available from the corresponding author.

Conclusions

Along with traditional RGP lenses there are several proprietary designs for irregular and aberrated corneas. Despite providing excellent vision and oxygen transmissibility, patients may be unable to tolerate rigid lenses or achieve their desired wearing schedules even when the lenses are fitting well. In these cases, piggyback may be considered. The idea of piggyback contact lens system is not new, nevertheless in the past, hypoxia reaction in compromised cornea was the major concern.[7] Now, the available hyper oxygen transmissible lens materials make these dual-lens systems a viable option for the compromised cornea.

References

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