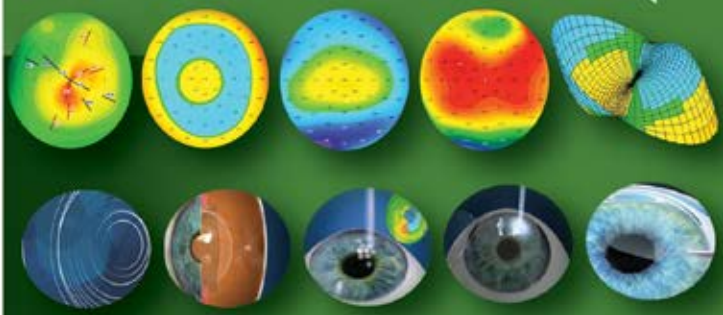
THIRD EDITION



Step by Step®

READING PENTACAM TOPOGRAPHY

(Basics and Clinical Applications)

Mazen M Sinjab

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Chapter 4

Tomographic Rules in Laser-based Refractive Surgery

This type is cornea-based. Subtypes can be categorized into surface photoablation and lamellar photoablation.

Surface photoablation consists of Photorefractive Keratectomy (PRK), Laser Subepithelial Keratomileusis (LASEK), Epipolis Laser in Situ Keratomileusis (Epi-LASIK), and Trans-Epithelial Photorefractive Keratectomy (TE-PRK).

Lamellar photoablation consists of Laser in Situ Keratomileusis (LASIK), Femtosecond Laser in Situ Keratomileusis (FemtoLASIK), sub-Bowman Keratomileusis (SBK), and Small Incision Lenticule Extraction (SMILE).

The subtypes of laser-based refractive surgery have rules in common and rules in specific. The rules in common are rules of K-readings, optical zone (OZ), cyclotorsion, recentration of the laser profile, and astigmatic disparity. The rules in specific are the thickness rules.

RULES OF REFRACTIVE ERROR MAGNITUDE

Table 4.1 shows the recommended range of correction of refractive error magnitude for surface ablation and LASIK. It is highly recommended to avoid corrections beyond the limits to avoid complications even if other rules allow for the correction. **Table 4.2** represents six examples.

Regarding the SMILE, there are two schools differing in the pre- and intraoperative treatment parameters. **Table 4.3** shows the parameters in the European CE Mark and the FDA Approval. **Table 4.4** represents six examples.

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Table 4.1: Range of refractive error magnitude to be treated.

	Myopic SE (D)	*Hypermetropic SE (D)*	*Astigmatism (D)*
Surface Ablation	Up to –8.00	Not recommended	Up to 2.00[a]
LASIK	Up to –8.00	Up to +6.00	Up to 6.00

(SE: spherical equivalent)
[a]Not recommended above 2.00 D because of the epithelial remodeling effect.

Table 4.2: Examples of range of refractive error magnitude.

Example	*Sphere (D)*	*Cylinder (D)*	*SE (D)*	*Surface Ablation*	*LASIK*
1	–4.00	–2.00	–5.00	✓	✓
2	–7.00	–3.50	–8.75	X	X
3	+3.00	+1.50	+3.75	X	✓
4	–9.00	0	–9.00	X	X
5	–2.50	–5.00	–5.00	X	✓
6	+2.50	–4.00	+0.50	X	✓

(SE: spherical equivalent)

Table 4.3: Parameters of SMILE treatment in CE mark and FDA approval.

Parameter	*CE Mark*	*2018 FDA Approval*
Sphere to be treated	–0.50 to –10.00 D	–1.00 to –10.00 D
Preoperative cylinder	No restriction	Up to –3.00 D
Cylinder to be treated	Up to –5.00 D	–0.50 to –3.00 D
SE to be treated	–0.50 to –12.50 D	–1.00 to –11.50 D
Preoperative SE	No restriction	Up to –11.50 D

(SE: spherical equivalent; SMILE: small incision lenticule extraction)

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Table 4.4: Examples of selection criteria in SMILE based on refraction.

	Preoperative Refraction			*Treatment Plan*				
Example	*Sphere (D)*	*Cylinder (D)*	*SE (D)*	*Sphere (D)*	*Cylinder (D)*	*SE (D)*	*CE Mark*	*2018 FDA Approval*
1	–3.00	–2.00	–4.00	Full correction			✓	✓
2	–6.00	–1.00	–6.50	Full correction			✓	✓
3	–11.00	–5.00	–13.50	–10.00	–3.00	–11.50	✓	X
4	–5.00	–4.00	–7.00	Full correction			✓	X
5	–10.00	–4.00	–12.00	–9.00	–2.50	–10.25	✓	X
6	–12.50	–3.00	–14.00	Full correction			X	X

(SE: spherical equivalent)

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THICKNESS RULES

Total refraction (TR) and central ablation depth (CAD) are used for thickness calculations.

1. *Calculating TR:* TR is the algebraic sum of the sphere and cylinder. **Table 4.5** represents six examples.
2. *Calculating CAD:* CAD depends on the magnitude and the type of the corrected refractive error, optical (OZ), and treated (TZ) zones, laser profile (optimized versus customized). In customized laser profiles, CAD can only be calculated by the machine software. Therefore, all calculations in this book will be based on the optimized laser profiles.

   In optimized laser profiles, CAD is calculated by Munnerlyn formula:

   $CAD = 1/3 \times (OZ \text{ in mm})^2 \times \text{intended correction in dioptres}$,

   where the intended correction is the TR in most softwares. To make the calculations more practical, follow **Table 4.6**. **Table 4.7** represents six examples.
3. *Thickness rules in surface ablation:*
   A. Preoperatively, CCT should be ≥470 µm (including the epithelium).
   B. Postoperatively, CCT should be ≥400 µm (including the epithelium).

Table 4.5: Examples of total refraction (TR).

Example	*Sphere (D)*	*Cylinder (D)*	*TR (D)*
1	−2.00	−4.00	−6.00
2	−3.00	−1.00	−4.00
3	+4.00	−1.50	+2.50
4	+5.00	+1.00	+6.00
5	+2.00	−3.00	−1.00
6	+2.00	−4.00	−2.00

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Table 4.6: Central ablation depth (CAD).

	TR	OZ		
		6.00 mm	6.50 mm	7.00 mm
CAD	Per –1.00 D	13 µm	15 µm	17 µm
	Per +1.00 D	0 µm	0 µm	0 µm

(TR: total refraction; OZ: optical zone)

Table 4.7: Examples of central ablation depth (CAD).

Examples	Sphere (D)	Cylinder (D)	TR (D)	CAD (µm)		
				OZ = 6.00 mm	OZ = 6.50 mm	OZ = 7.00 mm
1	–2.00	–4.00	–6.00	78	90	102
2	–3.00	–1.00	–4.00	52	60	68
3	+4.00	–1.50	+2.50	0	0	0
4	+5.00	+1.00	+6.00	0	0	0
5	+2.00	–3.00	–1.00	13	15	17
6	+2.00	–4.00	–2.00	26	30	34

(TR: total refraction; OZ: optical zone)

The postoperative corneal thickness after surface ablation is calculated as follows:

Postoperative CCT (including epithelium) = Preoperative CCT (including epithelium) – CAD

Table 4.8 shows six examples.

4. *Thickness rules in LASIK and FemtoLASIK:*
   A. Preoperatively, CCT should be ≥500 µm (including the epithelium).
   B. Postoperatively, Percent Tissue Altered (PTA) <40%.

PTA takes into consideration flap thickness (FT), CAD, and CCT. It is calculated by the formula:

$$PTA = (FT + CAD) \times 100/CCT$$

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Table 4.8: Examples of thickness rules in surface ablation.

Examples	TR (D)	CAD (μm) OZ = 6.50 mm	Preoperative CCT (μm)	Postoperative CCT (μm)	Surface Ablation
1	–8.00	120	480	360	X
2	–5.00	75	515	440	✓
3	+3.50	0	470	470	✓
4	+5.00	0	517	517	✓
5	–1.50	22.5	495	472.5	✓
6	–6.00	90	485	395	X

(TR: total refraction; CAD: central ablation depth; OZ: optical zone; CCT: central corneal thickness)

The normal PTA is <40%. **Table 4.9** represents six examples.

5. *Thickness rules in SMILE:* **Figures 4.1 and 4.2** illustrate SMILE components. As shown in these figures, the lenticule is composed between the cap (superior) cut and the refractive (inferior) cut, and it is extracted through the small side incision (the entrance incision). The corneal above the lenticule, including the epithelium, is called "the cap," and below the lenticule is called "the bed."

   In terms of thickness rules, the following rules are recommended:

   A. Preoperatively, CCT should be ≥470 μm (including the epithelium).
   B. *Intraoperatively:*
      i. *Cap thickness:* The recommended cap thickness ranges from 120 μm to 135 μm. The latter is preferable because it helps for future enhancement. If FemtoLASIK is planned for enhancement, a 100-μm flap will be safe enough to avoid interference with the epithelium above

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Table 4.9: Examples of percent tissue altered (PTA).

Examples	*TR (D)*	*CAD (μm) OZ = 6.5 mm*	*Pre-op CCT (μm)*	*PTA (%)*					*LASIK and FemtoLASIK*
				Flap = 130 (μm)	*Flap = 120 (μm)*	*Flap = 110 (μm)*	*Flap = 100 (μm)*	*Flap = 90 (μm)*	
1	–9.00	135	530	50	48.1	46.2	44.3	42.5	x
2	–6.00	90	520	42.3	40.4	38.5	36.5	34.6	✓ (Flap ≤110 μm)
3	+2.50	0	480	27.1	25	22.9	20.8	18.8	x
4	+6.00	0	512	25.4	23.4	21.5	19.5	17.6	✓
5	–1.00	15	487	29.8	27.7	25.7	23.6	21.6	x
6	–2.00	30	532	30.1	28.2	26.3	24.4	22.6	✓

(TR: total refraction; CAD: central ablation depth; OZ: optical zone; CCT: central corneal thickness; PTA: percent tissue altered)

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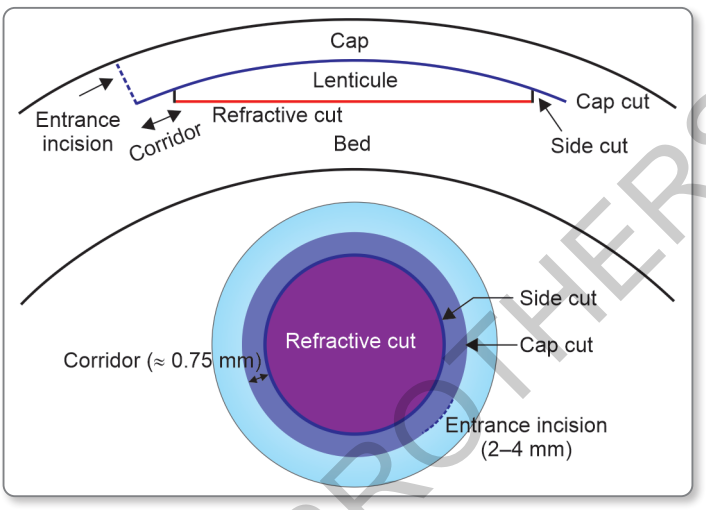


Fig. 4.1: Components of the small incision lenticule extraction (SMILE).

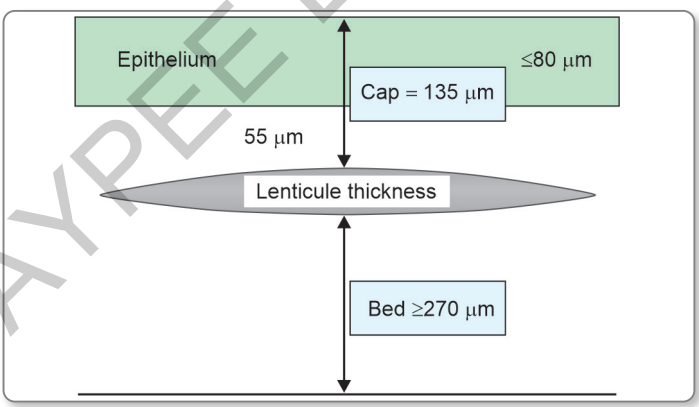


Fig. 4.2: Illustration of the small incision lenticule extraction (SMILE) showing the epithelium layer (≤80 μm), the recommended cap thickness (135 μm), and the recommended bed thickness (≥270 μm). These recommendations allow for future enhancement by LASIK and PRK.

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and the previous cap cut below. If PRK is planned for enhancement, the 55-µm stroma above the cap should be sufficient.

ii. *Side cut:* The myopic lenticule does not taper to 0 thickness at its edge. The edge is known as the side cut. The surgeon can choose the thickness of the side cut to be 10–30 µm. Most surgeons choose 15 µm. However, the thickness can be reduced to 10 µm in high myopic corrections (e.g., –10.00), and can be increased to 20–25 µm in low myopic corrections (e.g., –2.00).

iii. *Bed thickness:* The minimum should range between 250 and 280 µm. The latter is more preferable.

C. Postoperatively, CCT should be ≥400 µm (including the epithelium).

Table 4.10 represents six examples assuming that cap thickness is 135 µm and side cut thickness is 15 µm. These examples were calculated by using SMILE software.

Table 4.10: Examples of thickness rules in SMILE (Cap = 135 µm; Side = 15 µm).

Examples	*TR (D)*	*Preoperative CCT (µm)*	*OZ (mm)*	*Lenticule Thickness (µm)*	*Bed Thickness (µm)*	*Postoperative CCT (µm)*	*SMILE*
1	–8.00	550	6.5	135	280	415	✓
2	–5.00	515	6.5	93	287	422	✓
3	–3.50	495	7	82	278	413	✓
4	–10.00	520	6.5	161	224	359	X
5	–12.00	560	6.5	188	237	372	X
6	–6.75	545	7	137	273	408	✓

(TR: total refraction; CCT: central corneal thickness; OZ: optical zone)

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Table 4.11: Examples of thickness rules in SMILE (Cap = 120 µm; Side = 10 µm).

Examples	*TR (D)*	*Preoperative CCT (µm)*	*Optical Zone (mm)*	*Lenticule Thickness (µm)*	*Bed Thickness (µm)*	*Postoperative CCT (µm)*	*SMILE*
1	–8.00	550	6.5	135	300	415	✓
2	–5.00	515	6.5	93	307	422	✓
3	–3.50	495	7	82	318	413	✓
4	–10.00	520	6.5	161	244	359	X
5	–12.00	560	6.5	188	257	372	✓
6	–6.75	545	7	137	273	408	✓

(TR: total refraction; CCT: central corneal thickness; OZ: optical zone)

Table 4.11 represents the same examples in **Table 4.10**, but assuming that cap thickness is 120 µm and side cut thickness is 10 µm. These examples were calculated by using SMILE software.

K-READINGS RULES

The spherical equivalent (SE) is used in K-reading calculations. It affects the mean anterior K-reading (Km).

1. *Calculating the SE:* SE is calculated by the formula:

$$SE = Sphere + (Cylinder/2)$$

Table 4.12 represents six examples.

2. Calculating the predicted postoperative K-readings. In general, every –1 D SE correction reduces Km by 0.8 D, and every + 1 D SE correction increases Km by 1.25 D. Whatever the type of the refractive error, the SE is applied on the preoperative Km to predict the postoperative Km.

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It is a new addition to Professor Mazen Sinjab's outstanding books in ophthalmology. This edition is much different from the previous two editions in several points. It standardizes the method of capturing the cornea and excluding the sources of false findings. It presents two new algorithms—the Practical Subjective Scoring System (PS3) for laser-based refractive surgery and the Practical Subjective IOL Selection (PSIS) for lens-based refractive surgery. It also represents the new categorization of the ectatic corneal diseases, correlates the tomographic findings with their clinical applications, and highlights the importance of corneal wavefront in decision making. Moreover, this edition addresses the parameters, rules, and work-up of laser-based and lens-based refractive surgery as well as cataract surgery. Finally, it discusses four clinical cases in a systematic method to correlate tomographic findings with clinical decision making in refractive and cataract surgery. Professor Mazen Sinjab can be reached on mazen.sinjab@yahoo.com

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JP medical publishers

www.jpmedpub.com

ISBN 978-1-78779-129-9