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SMILE术后视觉质量的相关影响因素研究进展

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摘　要

角膜屈光手术是矫正屈光不正的方式之一。自从1979年前苏联眼科学家Fyodorov报道了放射状角膜切开术(RK)手术以来，角膜屈光手术经历了突飞猛进的发展，尤其是飞秒激光小切口角膜基质透镜取出术(femtosecond laser small incision lenticule extraction, SMILE)作为全新的角膜屈光手术方式更以极佳的手术安全性以及术后良好的视力而备受近视患者的青睐。SMILE术于2011年首次被报道，原理是通过小弧形切口取出角膜基质内透镜以矫正屈光不正。其优点包括干眼症状较少、术后炎性反应更轻、术后角膜生物力学较为稳定，并且因其无瓣，避免了与角膜瓣相关的并发症。长期以来，临床上主要以术后视力的恢复情况、是否出现并发症作为评判患者术后视功能的主要指标，而常常忽略患者的主观感受及客观测量指标(例如角膜像差等)，近年来近视术后视觉质量受到越来越多的关注，既往研究表明，术前屈光度、角膜高阶像差、角膜瓣(帽)的厚度等是角膜屈光手术后视觉质量的可能影响因素。本文主要对SMILE术后视觉质量的相关影响因素进行综述。

关键词

小切口角膜基质透镜取出术，视觉质量，像差

Research Progress on Related Factors of Visual Quality after SMILE

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Abstract

Corneal refractive surgery is one of the ways to correct ametropia. Since Fyodorov, a Soviet eye

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scientist, reported radial keratotomy (RK) in 1979, corneal refractive surgery has developed by leaps and bounds, especially Small Incision Lenticule Extraction (SMILE) as a new method of corneal refractive surgery, is favored by myopic patients because of its excellent surgical safety and good postoperative vision. SMILE was first reported in 2011. The principle is to remove the lenticule in the corneal stroma through a small arc incision to correct refractive errors. Its advantages include less dry eye symptoms, lighter postoperative inflammatory reaction, stable corneal biomechanics, and avoid complications related to corneal flap because of its absence of flap. For a long time, the recovery of postoperative visual acuity and complications are the main indexes to evaluate the visual function of patients after operation, but the subjective feelings and objective measurement indexes (such as corneal aberration, etc.) are often ignored. In recent years, more and more attention has been paid to the visual quality of myopia after operation. Previous studies have shown that preoperative diopter, high-order corneal aberration and thickness of corneal flap (cap) are the possible factors affecting visual quality after corneal refractive surgery. This article mainly reviews the related factors affecting visual quality after SMILE.

Keywords

Small Incision Lenticule Extraction (SMILE), Visual Quality, Aberration

1. 角膜高阶像差

波前像差一般情况下它分为 7 阶 35 项，3 阶及以上的称为高阶像差，是影响人眼视觉质量的主要因素[1]。既往研究认为 SMILE 术虽然有效消除了低阶像差对视力的影响，但手术引起的角膜损伤仍可能造成视疲劳和眩光等视觉不适症状，其原因与手术造成的角膜高阶像差(Higher-order aberrations, HOAs)升高密切相关[2] [3] [4]。Siedlecki 等[5]的一项基于主观 QoV 问卷[6] (基于 Rasch 模型)的研究中，SMILE 术引起的球差、彗差、三叶草像差以及总 HOA 增加，但其与患者报告的 QoV 评分或特定的长期视觉症状没有明显关系。Gyldenkerne 等[7]研究发现，尽管术后散光和角膜 HOA 在统计学上与术前有显著变化，但其对术后裸眼远视力(UCVA)无影响。

2. 屈光度

术前屈光度决定了透镜的形状以及术后角膜生物力学的变化[8]，从而影响视力的恢复速度。Tay 等[9]发现，SMILE 术治疗低度近视患者术后早期视力恢复较快，但术后 1 个月和 3 个月时视力恢复与术前等效球镜无明显相关性。一项针对高度近视患者行 SMILE 术后视觉质量的研究[10]显示，术后总 HOA、球差、垂直彗差均较术前明显增加，且 HOA 的增加与术前散光密切相关。一些研究[11] [12]表明，SMILE 术治疗散光时有轻微的欠矫正倾向。Pedersen 等[11]报道，SMILE 术散光欠矫正约 11%。Ivarsen 等[12]的研究显示，低度散光眼(<2.5D) SMILE 术后的矫正每 1.0D 欠矫正约 13%，高度散光眼(≥2.5D)每 1.0D 欠矫正约 16%；同时，术前散光越大，欠矫正程度越高。因此，部分学者建议 SMILE 术应在术前原有柱镜度的基础上增加 10%以对其进行足矫。

3. 角膜厚度

角膜相对较薄(预计透镜取出后角膜中央残留基质床厚度 < 250 μm)是 SMILE 术的禁忌证之一[13]。

Asli 等[14]关于薄角膜(最薄角膜厚度 < 500 μm 但符合手术要求)人群行 SMILE 术的一项研究认为，SMILE 术对角膜基底神经丛的损伤较小，对角膜生物力学完整性的影响较小。Skina [15]等认为，SMILE 术中去除组织的体积虽然对角膜薄的患者影响更大，但其与正常厚度角膜患者的手术安全性与视觉质量没有明显差别。由于薄角膜行 SMILE 术的相关研究相对较少，因此其术后视觉质量的变化仍需要进一步探讨。

4. 角膜帽厚度

SMILE 术角膜帽的厚度一般在 110~120 μm 之间[13]。一项关于在厚角膜(中央角膜厚度 > 560 μm)人群行 SMILE 术中使用不同角膜帽厚度(120 μm 和 140 μm)的 RCT 研究[16]中，两种不同帽厚度术后屈光状态、视力、对比敏感度和高阶像差的变化相似。该研究指出，在选择角膜帽厚度时，不应该盲目增加残留角膜基质的厚度，而忽略薄帽中可能增加的角膜形态学变化。Wu 等[17]发现，帽厚为 110 μm 的眼相对于帽厚为 140 μm 的眼有更多的局灶性不透明气泡产生。因此，适当增加角膜帽的厚度可能影响术后视觉质量，但是仍然需要进一步研究证实。

5. 飞秒激光能量水平

既往研究表明[18] [19]，调整能量水平可能会提高 SMILE 术后视力和缩短术后恢复时间。Ji 等[18]的一项关于术中飞秒激光能量水平的 RCT 研究发现，低能量水平(100 nJ、105 nJ 及 110 nJ) SMILE 术后早期视觉质量优于常规能量水平 SMILE 术，但长期视觉质量无明显差异。同时，使用较低飞秒激光能量水平的 SMILE 术也有可能在没有 OBL (Opaque bubble layer，不透明气泡层)的情况下产生更好的光学界面。Donate 等[19]对不同程度近视患者行了低能量水平 SMILE 术的前瞻性研究发现，低度近视组 1 天和中度和高度近视组 1 个月时，所有眼睛的 UCVA 均达到 20/20 或更好。低度近视组对比敏感度在术后 8 天时恢复至术前水平，中度和高度近视组在术后 1 个月时恢复至术前水平。因此，研究表明低能量水平和屈光度数均可能影响术后视力和视觉质量恢复时间。

6. 透镜偏中心

角膜屈光手术中治疗区的准确定位对获得良好的术后视觉效果起着至关重要的作用，虽然视轴的角膜交点是理想的中心点，但在实际应用中很难精确定位，因此难免会出现偏中心。Lee 等[20]发现，透镜偏中心程度越小，诱导的角膜高阶像差越低，视觉质量越好。Kang 等[21]的一项研究指出，三标线定位法 SMILE 术较主观定位法可以提高定位精度，减少总 HOA、彗差和球差；Liu 等[22]通过泪膜标记定位法也得到了类似的结果。最新研究[23]认为，在治疗近视、散光和大 kappa 角(>0.2 mm)的患者时，首选地形图对比法或泪膜标记定位法；当散光大于−3.50D 时，可谨慎使用地形图对比法定位角膜顶点。不过，关于 SMILE 中心定位方法和偏心测量方法的研究缺乏横向比较，未来可以对有效光学区与主观和客观视觉质量之间的相关性进行进一步的研究。

7. 角膜透明度

角膜的透明是其生理特性之一[24] [25]。Scheimpflug 成像技术能以角膜光密度(corneal densitometry, CD)测量值的形式对角膜透明程度进行客观和定量测量。基于其他角膜屈光手术的既往研究表明，CD 值可以很好地预测术后视力和视觉质量[26] [27] [28]。但最近基于 SMILE 术的一些研究似乎不支持这个观点。一项基于 SMILE 术后 CD 值与角膜高阶像差的临床研究[29]显示，SMILE 术后 CD 值和高阶像差均与角膜基质透镜中央厚度存在一定相关性，SMILE 术后 CD 值与角膜高阶像差之间无明显相关性。Liu 等[30]发现，SMILE 术后的 24 小时内的任何随访时间点的裸眼视力与 CD 值均无相关性。Shajari 等[31]

的 SMILE 术后 1 年的观察性研究指出，已知的 SMILE 术后视力恢复延迟与 CD 值变化无关。角膜屈光手术会引起角膜透明程度的变化，但是 SMILE 术后透明度的变化及其对于术后早期视觉质量的影响仍有待进一步阐明。

8. 总结

角膜屈光手术在我国的发展非常迅速，手术的安全性和有效性越来越受到医患双方的高度重视。在屈光可预测性、有效性、安全性和稳定性方面，SMILE 术能够在近视和近视散光的治疗中产生良好的结果[32] [33]。屈光手术治疗的最终目的不仅仅是提高视力，同时还要改善患者视觉功能，提高视觉质量。SMILE 术视觉质量的影响因素研究，可以为临床 SMILE 术后视觉质量的进一步改善提供理论依据。

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