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REFRACTIVE SURGERY IN ATHLETES: SAFETY, VISUAL PERFORMANCE AND RETURN-TO-SPORT CONSIDERATIONS - A NARRATIVE REVIEW

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ABSTRACT

Background: Optimal vision is performance-critical in many sports, while spectacles and contact lenses may impair comfort, safety, and reliability during training and competition. Corneal refractive surgery (photorefractive keratectomy—PRK, laser in situ keratomileusis—LASIK, small-incision lenticule extraction—SMILE) is increasingly considered by athletes, but procedure selection must balance visual quality, ocular-surface stability, biomechanical safety, and sport-specific trauma risk [1,4–7,19,20].

Aim: To synthesize contemporary evidence on safety, visual performance, and return-to-sport considerations after PRK, LASIK, and SMILE in athletic and athletic-like populations [1–8,19,20].

Material and methods: A narrative review was conducted using PubMed as the primary database (supplemented by manual reference chasing) for English-language human studies (2018–2025) addressing refractive surgery outcomes relevant to athletes: visual acuity/quality, contrast sensitivity and low-contrast acuity, dry eye and symptoms, ectasia/biomechanics, traumatic flap events, and occupational return-to-duty in visually demanding cohorts [1–8,13–17,19,20].

Results: Modern PRK, femtosecond LASIK, and SMILE provide high efficacy and safety in most appropriately selected patients [1–3]. SMILE and PRK avoid a permanent flap and may be preferable in high-impact/contact sports [9–11]. Visual quality (including low-contrast performance) generally recovers rapidly after LASIK/SMILE and more gradually after PRK [1,14,16,17]; dry-eye metrics tend to worsen most after LASIK, with smaller or nonsignificant changes reported after PRK/SMILE in meta-analytic evidence [4,5]. Ectasia remains rare but is linked to preoperative risk factors; reported ectasia after SMILE is uncommon in large cohorts [6,7]. Return-to-sport timelines are primarily based on healing biology and trauma risk rather than randomized evidence [19–21].

Conclusions: For athletes, procedure choice should be individualized by sport exposure, ocular-surface status, corneal tomography/biomechanical risk, and performance demands under glare/low contrast [4–8,14,16,17]. Flapless approaches (PRK/SMILE) are generally favored for contact sports; structured, staged return-to-sport with protective eyewear is recommended [9–11,19–21].

KEYWORDS

Refractive Surgery, Athletes, LASIK, PRK, SMILE, Visual Performance, Contrast Sensitivity, Dry Eye, Ocular Trauma, Return to Sport

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1. Introduction

Elite and recreational athletes rely on rapid visual processing, accurate depth perception, and stable optical quality under variable lighting, wind, dust, dehydration, and fatigue [19–21]. In many sports, refractive errors are corrected by spectacles or contact lenses, yet both modalities can be problematic: spectacles may restrict peripheral vision and fog; contact lenses can dry out, dislodge, or become intolerable during prolonged training, high airflow, chlorinated water exposure, or extended screen time during travel [4,5,19–21].

Corneal refractive surgery offers potential advantages for athletes: freedom from external optical aids, stable refractive correction, and improved convenience [1–3]. However, athletes represent a distinct decision context. First, some sports (combat sports, rugby, football, hockey) involve higher rates of ocular trauma, and a permanent corneal flap (LASIK) can be vulnerable to displacement even years after surgery, as highlighted by flap dislocation case reports and series [9–11]. Second, high-performance vision is not solely 20/20 acuity; low-contrast performance, glare tolerance, higher-order aberrations, and dry-eye symptoms can materially influence performance and comfort—particularly under night lighting, snow glare, or high-speed airflow [1,4,5,14,16,17]. Third, biomechanical safety (risk of postoperative ectasia) and long-term stability are central when athletes may be exposed to dehydration, eye rubbing, and repeated microtrauma [6,7,13].

While athlete-specific randomized trials are scarce, evidence from large clinical cohorts, meta-analyses, and visually demanding occupational populations (military service members and aviators) provides useful clinical signals about outcomes relevant to sport [1–3]. For example, prospective military evaluations of SMILE demonstrate high rates of uncorrected 20/20 vision and preserved quality-of-vision measures during task performance [1]. Long-term military follow-up indicates refractive stability and overall safety extending into many years after PRK/LASIK [2].

1.1. Aim of the review

This narrative review synthesizes contemporary evidence on:

- safety and complication profiles (including traumatic considerations) [6–11,17],
- visual performance metrics relevant to athletes (low contrast, contrast sensitivity, optical quality) [1,14,16–18],
- ocular-surface outcomes (dry eye and symptoms) [4,5],
- biomechanical considerations and ectasia risk [6,7,13],
- pragmatic return-to-sport recommendations informed by healing biology and risk stratification [19–21].

2. Material and methods

2.1. Review design

A narrative review approach was selected because athlete-specific controlled trials are limited and relevant data are distributed across clinical refractive surgery literature, occupational performance studies, meta-analyses, and trauma case series [1–3,9–11,17,19–21].

2.2. Search strategy

PubMed was searched as the primary database for publications from January 1, 2018 through December 31, 2025, supplemented by manual reference chasing of key reviews and meta-analyses [4–7,14,17]. Searches combined terms for procedures and outcomes: (“LASIK” OR “PRK” OR “photorefractive keratectomy” OR “SMILE” OR “small incision lenticule extraction”) AND (“athlete*” OR “sport*” OR “military” OR “aviator*” OR “task performance”) AND (“contrast sensitivity” OR “low contrast” OR “dry eye” OR “ectasia” OR “biomechanics” OR “trauma” OR “flap dislocation”). Priority was given to systematic reviews/meta-analyses, large cohorts, prospective studies, and recent evidence (last 5–7 years) unless classic foundational works were required for context [6,7].

2.3. Inclusion and exclusion criteria

Included:

- Human studies in English;
- Comparative outcomes (procedure-to-procedure) and/or clinically meaningful endpoints: UDVA/CDVA, refractive predictability, contrast sensitivity/low-contrast acuity, dry-eye parameters, ectasia incidence, flap complications, occupational/functional performance [1–8,14,16,17].

Excluded:

- Non-peer-reviewed promotional materials;
- Reports lacking sufficient methodological detail for interpretation;
- Animal-only studies (unless needed for mechanism and clearly labelled).

2.4. Data synthesis

Findings were synthesized thematically by clinical question (safety/trauma, visual performance, ocular surface, biomechanics/ectasia, return-to-sport) [4–8,14,16,17,19–21].

3. Results (thematic synthesis)

3.1. Procedures and athlete-relevant mechanism differences

PRK is a surface ablation technique: the corneal epithelium is removed, stromal ablation is performed with an excimer laser, and the epithelium regenerates over days. The absence of a stromal flap is a key advantage for contact sports, but recovery is slower and more uncomfortable early, with haze risk in higher corrections (mitigated by mitomycin-C in appropriate cases). Evidence supports mitomycin-C as an anti-haze strategy in PRK [15].

LASIK creates a corneal flap (commonly femtosecond-laser generated today) and ablates stroma beneath; it provides rapid visual recovery but introduces flap-related risks. Flap-related complications constitute a substantial portion of LASIK complications, and flap characteristics (thickness, uniformity) vary by technology [12].

SMILE is a flapless intrastromal procedure: a lenticule is created and extracted through a small incision, theoretically preserving anterior stromal integrity and corneal nerves more than LASIK. Reviews of corneal biomechanics after SMILE, PRK, and LASIK highlight ongoing debate about relative biomechanical impact; available evidence suggests differences exist but are nuanced and dependent on correction magnitude and stromal tissue removed [13].

Athlete-relevant implication: In sports with high risk of blunt trauma to the eye, procedures that avoid a permanent flap (PRK/SMILE) are generally favored, while LASIK may be acceptable for low-contact sports when other factors (fast return, low discomfort) are prioritized and protective eyewear is feasible [9–11,19–21].

3.2. Safety and predictability in visually demanding populations

Although direct athlete cohorts are uncommon, occupational groups with performance requirements (military, aviators) approximate many athlete constraints: demanding vision, physical activity, and operational timelines [1–3].

SMILE: A prospective study in U.S. military service members undergoing SMILE demonstrated high efficacy (UDVA $\geq 20/20$ in 96% of eyes at 3 months), favorable safety indices, and preserved quality-of-vision measures relevant to task completion. Importantly, participants completed marksmanship tasks postoperatively, suggesting functional adequacy in visually demanding contexts [1].

PRK in aviators: Occupational outcomes in young military aviators undergoing PRK demonstrated high rates of return to duty standards and long-term “survival” of uncorrected 20/20 performance over years, with low complication rates in a structured program [3].

Long-term military stability: Long-term follow-up of military refractive surgery outcomes indicates that refractive shifts over time are modest and that overall safety is maintained over many years [2].

Critical appraisal: These studies are not randomized athlete trials and may have selection bias (stringent screening, controlled follow-up). However, they provide higher external validity for performance-oriented decision-making than general consumer case series alone [1–3].

3.3. Visual performance beyond Snellen acuity: low-contrast, contrast sensitivity, and aberrations

3.3.1. Low-contrast and task-relevant vision

Athletes frequently compete under suboptimal contrast conditions (stadium lighting, fog/rain, night play, glare) [1,19–21]. In the U.S. military SMILE study, low-contrast visual acuity under night-vision conditions showed measurable changes from baseline, emphasizing that even with excellent Snellen outcomes, contrast-related performance should be assessed [1].

Evidence also suggests contrast sensitivity can improve postoperatively in some contexts; for example, studies evaluating contrast sensitivity metrics after SMILE have reported postoperative improvements and relationships to refractive change [14]. While such findings are encouraging, they are often derived from controlled testing environments and may not directly translate to sport-specific outcomes (e.g., tracking a fast ball under glare) [14,19–21].

3.3.2. Higher-order aberrations (HOAs)

HOAs and induced optical phenomena (glare/halos/starbursts) can affect athletes, particularly in night sports or precision sports (shooting, golf) [16–18]. Matched-design comparisons of corneal HOAs after SMILE relative to femtosecond LASIK and PRK have been reported, with differences influenced by optical zone, decentration, and pupil size [16]. Systematic reviews/meta-analyses comparing wavefront-guided LASIK versus SMILE also evaluate aberration outcomes and generally find comparable safety/efficacy with nuanced differences in certain optical metrics [17].

Critical appraisal: HOA differences are often statistically significant but may be clinically small for many patients. For elite athletes who operate near performance margins, preoperative counseling should include the possibility of glare/halos, and postoperative testing should include functional assessments (e.g., contrast sensitivity, low-contrast acuity, glare testing) rather than relying on Snellen alone [14,16–18].

3.4. Ocular surface and dry eye: relevance to training, travel, airflow, and screen exposure

Dry eye is one of the most frequent postoperative symptoms across refractive procedures and is particularly relevant for athletes exposed to airflow (cycling, skiing), dry environments, and dehydration [4,5]. A meta-analysis evaluating dry eye outcomes after refractive surgery reported significant reductions in tear production and tear break-up time after LASIK, whereas reductions after SMILE/PRK were smaller or nonsignificant in pooled analyses [4]. A dedicated review of dry eye after SMILE discusses mechanisms and compares SMILE with femtosecond LASIK, emphasizing nerve transection differences and recovery trajectories [5].

Practical implication for athletes:

- Athletes with pre-existing ocular surface disease or contact lens intolerance may benefit from approaches with potentially lower dry-eye burden (often SMILE or PRK, depending on candidacy) [4,5].
- Postoperative regimens should be strict: preservative-free lubricants, environmental modifications, and objective monitoring where relevant [4,5].
- Symptoms can be performance-limiting even if clinical tests are “acceptable”; patient-reported outcomes matter [4,5].

Critical appraisal: Dry eye studies vary widely in definitions, tests (Schirmer, TBUT, osmolarity), follow-up time, and baseline risk factors. Meta-analytic conclusions should be interpreted as directional rather than deterministic for individuals [4,5].

3.5. Biomechanical safety and ectasia risk: screening is the decisive variable

Postoperative ectasia is rare but vision-threatening and thus highly relevant for athletes and clinicians who prioritize long-term reliability. A systematic review of ectasia after corneal refractive surgery synthesizes global data and emphasizes the central role of preoperative risk stratification (tomography/topography, corneal thickness, residual stromal bed, and related metrics) [6].

Ectasia after SMILE: Large cohort evidence from a high-volume refractive surgery center reports low early postoperative ectasia incidence after SMILE (approximately 0.15%), with most cases occurring in “borderline” eyes by predefined criteria [7].

Athlete-specific interpretation: Athletes may be tempted to “push eligibility” to minimize downtime; this is precisely the scenario where ectasia risk becomes unacceptable. Screening and conservative candidacy thresholds are more important than nominal procedure choice [6,7].

3.6. Trauma considerations: flap vulnerability and sport category

The most athlete-specific safety issue in corneal refractive surgery is traumatic exposure [19–21].

3.6.1. LASIK flap displacement: timing and persistence of risk

Case reports and literature reviews document traumatic flap dislocation years after LASIK, including events up to 10 years postoperatively [9]. Acute blunt trauma can cause flap displacement even weeks after surgery, as described in classic case literature [10,11].

While such events are uncommon, their relevance is amplified in contact sports where blunt periocular impacts are plausible [19–21]. Flap complications and outcomes after repositioning have been studied; a retrospective analysis of acute flap dislocations/striae indicates that flap repositioning can salvage vision effectively in most cases, but risk factors and morbidity exist [8].

3.6.2. Ocular injury epidemiology as contextual risk

Sports ocular injuries vary by sport type and protective equipment. Reviews of sports-related ocular injuries support the principle that high-contact and projectile sports carry meaningful risk of blunt/penetrating eye trauma [19,20]. For refractive surgery counseling, this supports stratifying sports into risk tiers [19–21].

Sport risk stratification (pragmatic):

- High risk: boxing/MMA, rugby, ice hockey, lacrosse, basketball (elbows/fingers), football/soccer collisions, paintball/airsoft [19–21].
- Moderate risk: racquet sports, skiing/snowboarding (falls), cycling (falls/debris), water sports [19–21].
- Lower risk: running, rowing, swimming (infection rather than trauma), golf [19–21].

Procedure implications:

- High-risk contact sports: favor PRK or SMILE (no flap); emphasize protective eyewear where feasible [9–11,19–21].
- Moderate risk: individualized; LASIK may be acceptable with counseling and protection [8–11,19–21].
- Low risk: any procedure appropriate if other candidacy factors favor it [1–7].

4. Discussion

4.1. Interpreting “performance benefit” without athlete RCTs

A central limitation in this field is the mismatch between what athletes care about (real-world performance) and what refractive surgery studies commonly measure (Snellen acuity, refraction). Occupational performance studies partially fill this gap: the U.S. military SMILE cohort incorporated task-relevant testing and quality-of-vision assessment [1]. Such evidence supports the plausibility that modern refractive surgery can meet performance demands, but it does not prove sport-specific advantage [1,19–21].

Therefore, clinicians should avoid over-claiming “performance enhancement” and instead frame refractive surgery as “removal of optical barriers” (fogging, lens instability, field restrictions), which may indirectly improve consistency and comfort [1,4,5].

4.2. Choosing between PRK, LASIK, and SMILE in athletes: a decision framework

4.2.1. If contact trauma risk is high

Flapless approaches dominate decision-making. The long-term possibility of traumatic flap displacement—even if rare—makes LASIK less attractive for combat sports or frequent collisions [9–11]. PRK and SMILE reduce this specific vulnerability, though they have their own trade-offs (PRK recovery/haze; SMILE enhancement logistics and access) [13,15].

4.2.2. If rapid visual recovery is essential (short off-season)

LASIK and SMILE generally provide faster functional recovery than PRK. For athletes with narrow competition windows, SMILE may provide a compromise: relatively rapid recovery with flap avoidance. The U.S. military SMILE data support functional adequacy after early recovery [1].

4.2.3. If ocular surface symptoms are a major issue

Dry eye can derail training consistency. Meta-analytic data suggest LASIK is more strongly associated with reductions in tear production/TBUT, while SMILE and PRK show smaller changes in pooled analyses [4,5]. In symptomatic or high-risk athletes, SMILE or PRK may be favored, though individualized assessment is mandatory [4,5].

4.2.4. If ectasia risk is borderline

No procedure should be used to “solve” poor candidacy. The ectasia literature consistently indicates that screening and risk scoring are the gatekeepers of safety [6,7]. SMILE ectasia is uncommon but real and concentrated in borderline eyes in cohort data [7]. For athletes, conservative candidacy thresholds are appropriate [6,7].

4.3. Return-to-sport: evidence, uncertainty, and a staged protocol

There is no universal randomized evidence for return-to-sport timelines after refractive surgery. Recommendations are therefore based on: epithelial healing (PRK), flap adherence and interface vulnerability (LASIK), incision healing and inflammation (SMILE), infection risk (water exposure), and trauma risk of the sport [19–21].

A staged, sport-tiered approach is clinically defensible:

Stage 1: Immediate postoperative period (Days 0–3)

No sport; protect eyes from rubbing, dust, sweat [4,5].

Emphasize adherence to drops; avoid gyms with poor hygiene [4,5].

Stage 2: Early recovery (Days 3–14)

LASIK/SMILE: light aerobic activity may be considered if there is no eye rubbing risk and sweat exposure is minimized (band/headwear, frequent lubrication) [4,5].

PRK: typically longer discomfort and epithelial recovery; many athletes will not tolerate training and should prioritize healing [15].

Avoid swimming and contact sports (infection + trauma risk) [19–21].

Stage 3: Controlled training (Weeks 2–6)

Non-contact training can usually resume progressively, emphasizing protective eyewear if environmental debris is likely [19–21].

For sports with projectile risk (racquet sports), protection is strongly recommended based on general ocular injury literature [19–21].

Stage 4: Full return including contact (after Week 4–12 depending on sport/procedure)

High-contact sports require the longest delay and strict eye protection where feasible, particularly after LASIK due to flap considerations supported by flap-dislocation literature [8–11,19–21].

Key point: “Return” should be defined functionally, not just chronologically: stable refraction, adequate ocular surface comfort, acceptable night/contrast performance, and no significant inflammation [1,4,5,14,16,17].

4.4. Practical preoperative counseling checklist for athletes

1. Sport risk tier (contact/projection/falls/water exposure) [19–21].
2. Competition calendar (off-season window; travel).
3. Visual demands (night play, glare, precision tasks) [1,14,16–18].
4. Ocular surface evaluation (symptoms, meibomian dysfunction, prior CL intolerance) [4,5].
5. Tomography/tissue metrics (ectasia risk; do not compromise) [6,7].
6. Expectations management: vision may be 20/20 yet still feel “off” under glare/low contrast early [14,16–18].
7. Protective eyewear plan: especially for racquet/contact sports [19–21].

5. Conclusions

Modern corneal refractive surgery (PRK, femtosecond LASIK, SMILE) is generally safe and effective in appropriately screened patients, with high rates of excellent uncorrected visual acuity and favorable predictability [1–3]. Evidence most relevant to athletes derives from high-demand occupational cohorts and contemporary meta-analyses rather than athlete-specific RCTs [1–3]. Prospective military data suggest SMILE can preserve quality-of-vision measures and support functional task performance after early recovery, while long-term military follow-up supports stability and safety of refractive surgery over years [1,2]. Dry eye remains a common issue, with pooled evidence indicating greater tear-film impact after LASIK compared with smaller or nonsignificant changes after PRK/SMILE [4,5]. Ectasia is rare but serious; rigorous preoperative screening is the primary determinant of long-term safety, and reported SMILE ectasia incidence in large cohorts is low but concentrated in borderline eyes [6,7].

For athletes, procedure choice should be driven by sport-specific trauma exposure and performance context [19–21]. Flapless procedures (PRK/SMILE) are generally preferred for contact sports due to documented potential for traumatic LASIK flap displacement even years after surgery [9–11]. Return-to-sport decisions should be staged, individualized, and function-based, with particular emphasis on ocular surface stability, contrast performance, and protective eyewear in higher-risk environments [1,4,5,14,16,17,19–21]. Future research should prioritize sport-specific functional endpoints, standardized low-contrast/glare testing, and prospective registries capturing trauma events and return-to-play outcomes across procedures [1,19–21].

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