Corneal Laser Refractive Surgery Curriculum Development in the Military

By

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ABSTRACT

Corneal Laser Refractive Surgery Curriculum Development in the Military

Charisma B. Evangelista, MD, 2021

Thesis directed by Anita Samuel, PhD, Assistant Professor and Chair of Student Promotions Committee, Center for Health Professions Education, Uniformed Services University of the Health Sciences, Bethesda, MD; Kelsey L. Larsen, PhD, Assistant Professor, School of Politics, Security, and International Affairs, University of Central Florida, Orlando, FL; and Ronald M. Cervero, PhD, Professor and Deputy Director, Center for Health Professions Education, Uniformed Services University of the Health Sciences, Bethesda, MD.

Purpose: Corneal laser refractive surgery (CRS), otherwise known as laser vision correction, includes eye procedures such as laser-assisted in situ keratomileusis (LASIK), photorefractive keratectomy (PRK), and small-incision lenticule extraction (SMILE), which aim to rid people of their prescription glasses. As CRS is becoming more prevalent and has become a valuable component of military combat readiness, this thesis aims to develop a standardized curriculum for CRS training in the military.

Methods: This project is guided by the Six Step Approach to Curriculum Development as described by Patricia Thomas and David Kern. The Nominal Group Technique (NGT) was used to establish expert consensus on curriculum components for CRS training in the military. The International Council of Ophthalmology (ICO) refractive surgery curriculum, National Curriculum for Ophthalmology Residency Training, Accreditation Council for Graduate Medical Education (ACGME) competencies and surgical minimums, and American Academy of

Ophthalmology Refractive Surgery Preferred Practice Guidelines were used as the starting materials from which panelists' consensus was drawn.

Results: Using the NGT, this study was able to reach consensus on the components of a standardized military CRS curriculum to include generalized and targeted needs assessment, goals and objectives, educational strategies and curriculum implementation.

Conclusion: This thesis is the first effort towards standardization of CRS curriculum in the military. Guided by current practice guidelines and expert clinical experience, this study established a consensus on the goals, objectives, educational methods, and implementation strategies of a unified CRS curriculum that may also serve as a stimulus for standardizing both current and future training programs.

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Chapter 1: Introduction

Background and Purpose

Corneal laser refractive surgery (CRS) is an elective procedure that corrects refractive errors such as nearsightedness, farsightedness and astigmatism, allowing individuals to become independent of prescription eyeglasses. Currently, CRS includes photorefractive keratectomy (PRK), laser-assisted in situ keratomileusis (LASIK) and small-incision lenticule extraction (SMILE). PRK and LASIK were FDA approved in 1995 and 1998, respectively, and have been adopted in the military since early 2000. SMILE was FDA approved in 2016 and has been incorporated in military refractive surgery centers since 2018. As refractive surgery has become more prevalent, more ophthalmologists need to learn about treatment options as well as management of complications in order to meet increasing patient demand.

Currently, little is known about the most effective curriculum for teaching CRS in training programs. There is no published guideline or criteria on what defines an effective CRS training program. Many attending surgeons of ophthalmology residency programs are still learning how to perform the different CRS procedures themselves. Challenges of CRS training programs not only include limited attending surgeon experience, but also the fact that laser refractive surgery is generally considered an elective or cosmetic procedure. Therefore, it is more difficult to justify the need to train residents in this costly procedure.

In the military, however, CRS is not considered a cosmetic procedure, but an essential procedure that impacts deployment readiness of military service members. CRS allows military members to see well without eyeglasses or contact lenses. Eyeglasses often get in the way of head gears such as night vision goggles, helmets or gas masks. If someone deploys with eyeglasses and they lose their glasses in the middle of a firefight, they may be putting their lives and others' lives at risk if they cannot see well enough to complete their mission. Contact lenses may cause irritation and infection if overworn or if worn in a dirty environment. This makes contact lenses unsafe in a deployed environment. Thus, CRS is a valuable readiness asset in the military and CRS training is mandatory in military ophthalmology residency programs. Because of this, it is important to develop an effective laser refractive surgery residency training program in the military to produce competent laser refractive surgeons.

Currently, each military service branch conducts a separate CRS training program incorporated in their ophthalmology curriculum. However, it is unknown what is involved in each curriculum. The goal of this study is to develop a standardized curriculum for CRS training in the military.

Theoretical and conceptual framework

This study uses a constructivist approach which assumes that there is no one simple static effective refractive surgery training program. What are considered effective components of a successful program this year will likely evolve in future years depending on the demands of the mission, values and expectations of the surgeons, residents, patients as well the availability and cost of current technology.

Since there is no established CRS curriculum, we utilized Kern's Six Step Approach to Curriculum Development to serve as a conceptual framework in creating the methodology for this study. The Six Step Approach defines curriculum as a "planned educational experience" composed of goals, objectives, content, educational methods, implementation strategies, evaluation and feedback.[13] As we reviewed the literature, we searched for these individual curriculum components that are possibly being utilized by ophthalmology training programs. We found four key documents from national and international ophthalmology societies and governing bodies that describe goals, objectives, and content recommended in CRS training as part of a broader ophthalmology curriculum. These are the International Council of Ophthalmology (ICO) refractive surgery curriculum, the National Curriculum for Ophthalmology Residency Training, the Accreditation Council for Graduate Medical Education (ACGME) competencies and surgical minimums, and the American Academy of Ophthalmology Refractive Surgery Preferred Practice Guidelines. However, the goals and objectives listed in these documents are broad and non-specific, which makes implementation difficult. Furthermore, there were no guidelines on effective educational methods, implementation strategies, evaluation or feedback tools applicable to CRS training. Nevertheless, these four documents served as good starting materials for CRS curriculum content.

Methodology: The Nominal Group Technique

This study was conducted using the Nominal Group Technique (NGT) after obtaining approval and exempt status from the 59th Medical Wing Joint Base San Antonio Institutional Review

Board. NGT is a consensus development technique wherein a panel of experts, in this case currently practicing military refractive surgeons involved in a refractive surgery training program, arrive at a consensus on an effective corneal laser refractive surgery curriculum needed to develop a competent refractive surgeon. This consensus-building method allows for equal representation of experts' ideas and fosters collaboration in order to develop ideas in an efficient manner.[14,16,21] Compared to other consensus building techniques such consensus development panels and Delphi technique, the NGT is more appropriate when there is paucity in literature or when a standard does not exist. The ICO refractive surgery curriculum and National Curriculum for Ophthalmology Residency Training[10-11] were used as starting materials to guide the question prompts for this NGT session.

The NGT method employed in this study is similar to the technique used by Bell et al. in their paper on best practices of peer coaching for medical educators.[14] Twelve potential expert participants were identified for this NGT based on area of expertise and current refractive surgery faculty and leadership status. Eight experts agreed to participate, which was higher than the expected 30-50% participation rate from prior studies.[15]

This NGT was conducted using an online video conferencing platform as panelists were geographically separated. First, an introduction of the research purpose and method was given to the panelists. Then, question prompts regarding different components of an ideal CRS curriculum were given to allow for silent generation of ideas. The silent idea generation was followed by sharing of ideas and a group discussion. Finally, voting or ranking of ideas was

obtained anonymously to generate a consensus of curriculum description to develop the best curriculum for military CRS training.

Chapter 2: Corneal Laser Refractive Surgery Curriculum Development in the Military: Using the Nominal Group Technique

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Short title: CRS Curriculum Development in the Military

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Abstract

Introduction: Corneal laser refractive surgery (CRS) has emerged over the past three decades as a surgical method for correcting or improving vision. In the military, CRS helps warfighters achieve weapon grade vision, which offers a tactical advantage in the deployed environment. As refractive surgery has become more prevalent both in the military and civilian sector, more ophthalmologists need to learn about treatment options as well as management of complications in order to meet increasing patient demand. Currently, little is known about the most effective curriculum for teaching refractive surgery in training programs and a standardized curriculum does not exist. Since unification of training programs is a Defense Health Agency (DHA) priority, this study aimed to collect expert consensus on a standardized curriculum for CRS training in the military.

Materials and Methods: To achieve this goal, the Nominal Group Technique (NGT) was used wherein a panel of experts, currently practicing refractive surgeons involved in military refractive surgery training programs, arrived at consensus on a standardized CRS curriculum. The framework for developing this curriculum is based on Kern's Six Step Approach to Curriculum Development. The International Council of Ophthalmology (ICO) refractive surgery curriculum, National Curriculum for Ophthalmology Residency Training, Accreditation Council for Graduate Medical Education (ACGME) competencies and surgical minimums, and American Academy of Ophthalmology Refractive Surgery Preferred Practice Guidelines were used as the starting materials from which panelists' consensus was drawn. This consensus building method allowed for equal representation of experts' ideas and fostered collaboration to aid in the creation of a robust and standardized curriculum for refractive surgery training programs in the military.

Results: The panelist experts from this NGT were able to reach consensus on the components of a standardized military refractive surgery curriculum to include generalized and targeted needs assessment, goals and objectives, educational strategies and curriculum implementation. Conclusion: A standardized CRS curriculum is warranted in military training programs. This NGT achieved expert consensus on the goals, objectives, educational methods, and implementation strategies for a standardized CRS curriculum in military ophthalmology residency.

Introduction

Corneal laser refractive surgery (CRS), also known as laser vision correction (LVC), is a procedure that reshapes the corneal surface to allow more independence from spectacles (i.e., eyeglasses and contact lenses). It has emerged over the past three decades, yet because the technology is still evolving, little is known about the most effective curriculum for teaching refractive surgery including CRS in training programs. In 2009, it was reported that only about 50% of residency training programs in the United States had provided CRS experience to resident trainees.[1-3] In 2016, 50% of young ophthalmologists in practice for less than 6 years and ophthalmology residents surveyed by the American Society of Cataract and Refractive Surgery had never performed CRS.[4]

People are increasingly electing to have CRS to become more independent of eyeglasses and contact lenses. In the civilian sector, this choice is considered an elective cosmetic procedure. However, in the military, CRS enhances occupational performance of warfighters especially in the deployed environment, which makes it an essential component of combat readiness. Thus,

trained military ophthalmologists perform this surgery to qualified warfighters. Warfighters have increased tactical advantage after CRS as they are less dependent on corrective lenses that often get in their way during combat.[5] In 2010, Wright et al reported about 40-50% of United States Air Force (USAF) pilots and aircrew require corrective lenses to perform their duties. Their study also reported a prior survey that estimated about 50% of aircrew experience spontaneous loss of a corrective lens and about half of those lost their corrective lenses in flight.[6] The important role of CRS in helping service members decrease performance vulnerability explains the need for a standardized and robust refractive surgery curriculum to consistently ensure the quality of refractive surgery training in the military. In addition, as refractive surgery is becoming more common, more patients will likely present with a history of having had this surgery. Thus, it is essential that military and civilian ophthalmology residency programs incorporate refractive surgery evaluation, skills transfer and postoperative management training, especially to those who plan to perform refractive surgery after residency.[7]

There are a limited number of publications on CRS curriculum. The Accreditation Council for Graduate Medical Education (ACGME) requires that ophthalmology residents be trained in CRS procedures.[8] However, the ACGME only requires each resident trainee to perform or observe a minimum of six of these procedures. On the other hand, the Association of University Professors of Ophthalmology (AUPO) mandates cornea and refractive surgery fellows to perform a minimum of 8 and observe a minimum of 50 CRS procedures at the time of this study.[9] The International Council of Ophthalmology (ICO) has published a residency curriculum that includes a refractive surgery section listing the cognitive and technical skills recommended for refractive surgery training.[10] Similarly, in 2018, Grover et al[11] published a national curriculum for ophthalmology residency training. Although these references provide a list of competencies,

cognitive goals and surgical skills pertinent to CRS, they also combined all refractive surgery including CRS, phakic intraocular lenses, cataract surgery and clear lens exchange. Intermixing these different surgical approaches in one curriculum makes implementation and tracking competencies of all the different procedures particularly challenging. Furthermore, practical curriculum implementation requires more specific details such as CRS specific objectives and teaching methods than currently published that may be particularly helpful for novice staff and faculty who are considering CRS curriculum implementation.

The surgical minimum required by ACGME and AUPO does not guarantee clinical and technical competency for all CRS procedures. Furthermore, the lack of standardized curriculum requirements among training programs may lead to unintentional bias towards teaching select procedures that may not necessarily be the best procedure for every patient. Some procedures such as laser-assisted in situ keratomileusis (LASIK) and small-incision lenticule extraction (SMILE) can be technically more challenging, which require higher surgical volume experience. With the growing body of refractive surgery patients, training programs must be able to teach not only the technical aspect, but also the preoperative planning, counseling and postoperative management of the procedures. Developing a robust and unified curriculum may help all training programs produce competent refractive surgeons that would meet current and future demands of the Defense Health Agency (DHA).

In the military, a unified and highly reliable medical training system that would support readiness is a DHA[12] priority. A comprehensive ophthalmologist in the military may serve as the sole refractive surgeon in their local duty station, making the need for a standardized CRS curriculum to produce competent military refractive surgeons stark. Thus, the goal of this study

is to develop a standardized CRS curriculum for military training programs using a consensus method from experts in the field. This may then be further expanded into a more comprehensive curriculum that can help all training programs produce competent refractive surgeons who would meet current demands of a growing body of refractive surgery patients.

This study used the International Council of Ophthalmology (ICO) curriculum guide and National Curriculum for Ophthalmology Residency Training as baseline content guides, which both described the knowledge and skills ophthalmology residents and advanced trainees need to know in the area of refractive surgery. It also used *Curriculum Development for medical education: a six-step approach*[13] as an overarching framework to develop the curriculum components.

Methods

Nominal Group Technique

The Nominal Group Technique (NGT) used in this study was adopted from prior health professional research.[14-16] NGT was originally developed by Andre Delbecq and Andrew Van de Ven in the 1970s[17, 18] and has been used in curriculum development.[19, 20] This consensus-building method allows for equal representation of experts' ideas and fosters collaboration.[14, 21] The protocol has five steps: introduction and presentation of the nominal question to a group of experts, silent generation of ideas, sharing of ideas, group discussion, and voting/ranking of ideas. The goal is to arrive at a consensus defined in this study as >50% agreement among experts (adopted criteria from Bell et al[14]). After introducing the NGT process to the group, the

first question is presented by the moderator, followed by a period of silence for their independent thoughts. Then, in a round robin fashion, each expert shares their ideas without interruption from other panelists. All ideas are listed and visible to the group. The floor is then opened up for group discussion until all ideas are exhausted. Then anonymous voting or ranking of ideas transpires. In this study, this sequence of steps recurred for each question or topic of interest until the two-hour allotted time was finished. The 59th Medical Wing Joint Base San Antonio Institutional Review Board determined this study to be exempt from further review (Protocol FWH20200128E).

This NGT session was coordinated and conducted through an online video conference session due to the geographic separation of the participants. The principal investigator, who is a refractive surgeon and teaches refractive surgery to residents and fellows, moderated the session. Two assistant investigators provided technical assistance and logistical feedback. Two hours were allotted for this NGT, which was the ideal maximum time for NGT.[15, 16] Audiovisual recording of the session was saved with participant consent.

Prior to the session, the majority of the participants inquired about preparatory material. An optional questionnaire was sent out to participants that outlined the questions for the NGT. Questions were created based on *Curriculum Development for medical education: a six-step approach*,[13] ACGME competencies[22] and surgical minimums,[8] American Academy of Ophthalmology Refractive Surgery Preferred Practice Pattern,[23] ICO refractive surgery curriculum[10] and National Curriculum for Ophthalmology Residency Training.[11] Most participants opted to answer this pre-session questionnaire, but individual answers were only available to the moderator and not to other participants. This allowed the moderator to pre-list the range of possible answers in a polling system, and modify the list as needed during the

session, which made the voting/ranking portion more efficient. At the beginning of the session, the moderator reviewed the NGT process and the definition of a curriculum based on *Curriculum Development for medical education: a six-step approach*.[13] Upon the conclusion of the NGT, voting results were shared with the group.

Expert Panelists

At the time of this study, there were four ophthalmology residency programs across the United States Air Force, Army, and Navy that incorporated refractive surgery training. Upon institutional review board (IRB) approval, experienced military refractive surgery faculty members from these training programs were identified as potential participant experts for the NGT. To be considered eligible experts, participants had to be subject matter experts who were currently practicing and teaching refractive surgery and had the authority to implement changes.[16] A total of twelve potential participant experts were identified and invited through e-mail to participate in this NGT. The e-mail also described the purpose of the study. Agreement through an email response served as participant consent. Participants were able to opt out of the study at any time prior to or during the session if they desired. Eight experts (Table 1) agreed to participate, a higher participation rate than prior reports of 30-50% participation.[15]

The participants were composed of active duty military field grade officers (O-4 to O-6) who have also led their respective refractive surgery centers. All of them were at least 5 years out of residency and had been in clinical refractive surgery practice for at least 3 years -- half of them for over 10 years. Six were fellowship-trained in Cornea and Refractive Surgery. Each held leadership and/or teaching positions in refractive surgery at the time of this study.

Data Analysis

Both quantitative and qualitative data were gathered and analyzed in this study. The voting and ranking results captured through an automated polling system were used to quantitatively identify consensus agreement for each key idea. The primary investigator transcribed the video recording and de-identified the data for qualitative analysis. We used inductive content analysis as described by Patton,[24] which allows data verification of key information using multiple responses from participants.[16] Specifically, qualitative data from the transcription including individual ideas and group ideas were used to further contextualize the voting results and look for patterns or emerging themes not captured in the voting results. In this study, expert statements were used in order to: 1. obtain quotes to support identification of best practices, 2. clarify the context of the expert consensus obtained from voting, and 3. add depth to some of the expert answers.

Results were organized and analyzed in a spreadsheet, which was created and audited by two investigators (CE and AS) to enhance trustworthiness and validity. A third investigator (KL) helped with clarification of conflicting analysis when needed.

Results

General Needs Assessment

The NGT participants in this study acknowledged that the development of highly competent CRS surgeons to enhance warfighter vision directly supports military mission. They also recognized that a standardized CRS curriculum was nonexistent at the time of this study. Since

individual military service branches have different CRS curricula but share the same mission, the participants agreed unanimously that there is a general need for unification of all military CRS curricula in order to produce competent military refractive surgeons. They also agreed that this is in line with the DHA mission to integrate the Department of Defense (DoD) medical force and enhance warfighter readiness through collaboration and standardization of training and education.

Targeted Needs Assessment

The participants recognized that each military refractive surgery training center follows their own pre-existing curriculum built independently from other centers. The details and components of each curriculum are currently unknown to other training programs. The CRS skill level of each military ophthalmology resident varies depending on their training locations. And oftentimes military ophthalmologists need to go to a remote duty station and serve as an independent refractive surgeon immediately after residency training, which is a different expectation compared to their civilian counterparts. Because of this, the participant experts in this NGT agreed that US military ophthalmology residents should be trained under a standardized curriculum sharing the same goals, objectives and educational methods to become competent refractive surgeons.

Goals and Objectives

A summary of the goals and objectives the participants identified can be found in Table S1.

Broad program goals

The participant experts agreed that the primary goal of the military CRS curriculum is to teach military ophthalmology residents LASIK and photorefractive keratectomy (PRK) procedures. Different refractive surgery centers have different laser platforms so training and certification on more than one laser platform would be ideal. However, since case volumes may be limited in training programs, they recommended that trainees should at least prioritize familiarization with the same laser platform they will be using at their duty station. One of the participants mentioned a possible future goal is standardization of laser platforms in order to have a more uniform training.

The participant experts felt that small-incision lenticule extraction (SMILE), which is a newer FDA-approved CRS procedure, should eventually be incorporated in the CRS curriculum. However, at the time of this study, the industry required at least 50 LASIK cases performed prior to SMILE certification, which significantly adds to the number required from each trainee and is currently not feasible in military residency. In addition, the consensus in this NGT was that SMILE needed more advanced surgical skills that may not be consistently attainable during residency. Because of the above constraints, the participants reached consensus that SMILE should not be required during residency training.

The experts agreed that at least an introduction to implantable collamer lens (ICL) implantation should be incorporated in CRS curriculum because it is another refractive surgery alternative for qualified candidates. However, experts felt that it also requires more specialized surgical skills that may not be acquired during residency due to resource and volume limitations similar to SMILE.

Specific program objectives

The consensus in this NGT was that the majority (>70%) of trainees should achieve laser certification on at least one excimer and one femtosecond laser platform during residency. The participants emphasized, however, that the volume of training is more important than the type or brand of laser platform.

The experts agreed that residents must personally examine and consent all patients prior to participating in surgery. Residents need to review all test results and plan all treatments under the supervision of a staff surgeon. Some of the experts recommended reviewing and planning at least 50 to 100 patient charts with a supervising surgeon during training in order to gain the skills of discerning what patients qualify or do not qualify for CRS. In addition, the experts agreed that trainees need to accomplish a minimum of 5 comprehensive preoperative screening from start to finish, which includes personally doing the screening tests that technicians often perform such as manifest and cycloplegic refraction, topography, tomography, pupillometry and wavefront aberrometry. This is to ensure that surgeons know how to do the entire evaluation themselves and be able to verify all test results in their clinical practice.

In terms of the number of procedures performed, the experts agreed that a higher volume than what is required for certification is optimal. This will increase the chances of skill sets being ingrained and retained longer as in-processing to the next duty station takes time. Based on this consensus, the surgical minimum requirement per trainee should be 5 to 10 PRK and 21 to 25 LASIK procedures. They emphasized that the surgeon's technical skill set is different from the surgical planning skill set. The latter is much more difficult and is the skill that gives residents confidence to make the treatment decision and ultimately perform the procedure. Thus, surgical

planning requires a higher number of cases compared to the surgical minimum as previously suggested.

The experts also agreed that trainees should, at a minimum, see postoperative patients at postoperative day 1, week 1 and month 1 for PRK, and postoperative day 1 and week 1 for LASIK. Overall, the consensus was that the earlier postoperative visits provide more valuable teaching for LASIK, while later postoperative visits have more pertinent teaching points in PRK. There was no consensus on the minimum number of post-PRK patients trainees should see. However, they agreed that trainees should see 16 to 20 post-LASIK patients in order to see the gamut of conditions and interventions that may transpire after surgery. This may also help trainees inform their patients better during the consent process.

Educational Strategies

The top five methods that were unanimously voted to be absolutely needed when teaching CRS include using a tomography and topography teaching guide, demonstration of live surgery by the staff surgeon, direct observation during preoperative evaluation, direct supervision during surgery and direct supervision during postoperative visits. Other educational strategies and lecture topics that reached consensus of being absolutely needed and those that were deemed to be nice to have are all listed in Table 2.

Implementation

Due to the intrinsic technical differences between PRK and LASIK, the experts felt that it is appropriate to introduce PRK during the second year of residency (postgraduate year or PGY 3) and LASIK during the third year of residency (or PGY 4). Attending faculty need to be available

and willing to accommodate the number of trainees. Ideally, there is a 1:1 faculty to trainee ratio at any given teaching session. Consensus faculty qualifications such as 1 to 2 years of clinical experience as well as over 100 total procedures performed were believed to be necessary. Other items that experts felt are key to curriculum implementation, such as command support, staff training and support staff availability, are all listed in Table 3.

Evaluation and Feedback

Due to the time constraints allotted for an NGT, this section was not explored in this study. The main evaluation and feedback forms utilized by military training programs at the time of this study included generalized ophthalmology evaluations forms required by ACGME, but were not yet validated specifically for military CRS curriculum. The authors deemed a separate study should be conducted to explore the standardization of the Evaluation and Feedback tools for a CRS curriculum.

Discussion

Effective CRS training, including PRK, LASIK and SMILE, is becoming more relevant as the number of general population with CRS increases. In the military, its relevance is more emphasized in terms of deployment readiness; CRS allows for independence from eyeglasses which has a valuable impact downrange when warfighters need to wear specific headgear or goggles where prescription eyeglasses may be in the way. This emphasizes the importance of consistently producing competent CRS surgeons through curriculum improvement and standardization, which is integral to the DHA mission.[12]

The unique mission of the military validates the need for curriculum standardization within military training programs. We used *Curriculum Development for medical education: a six-step approach*, which defines curriculum as a "planned educational experience" and curriculum development as a process composed of problem identification, general and targeted needs assessment, and development of goals, objectives, educational strategies, implementation plan, and evaluation and feedback tools.[13]

This study established consensus that CRS curriculum in the military should at least prioritize teaching PRK and LASIK to military ophthalmology residents because these are the most prevalent treatment platforms in their immediate duty stations at the time of this study. Another CRS procedure, SMILE, was felt by the expert panelists to be more appropriate for advanced CRS surgeons and not necessarily required during military ophthalmology residency training.

Increasing surgical volume to more than what is currently required for certification was found to be optimal. However, the experts agreed that it is even more important to focus on the amount of preoperative evaluations trainees perform including chart reviews and surgical treatment planning in order to solidify their CRS training and ensure consistent delivery of excellent results.

In support of the goals and objectives, this NGT also established a consensus list of educational strategies mainly focusing on demonstration of skills and direct supervision of trainees by the attending surgeon during the preoperative evaluation, actual surgery and postoperative visits. The experts were able to reach consensus on items relevant to successful curriculum implementation such as organizational support, staff training, teaching facility and equipment.

The experts notably agreed that a qualified teaching faculty does not necessarily require cornea and refractive surgery fellowship as long as they have significant CRS experience defined in Table 3. Finally, it was also realized during this NGT that standardized feedback and assessment tools still needed to be developed.

We chose NGT to establish a consensus baseline curriculum that allowed collaboration and development of ideas with equal representation from all panelists.[14-16, 18] It also allowed immediate feedback and availability of results.[14, 16] Furthermore, in the setting of the COVID-19 pandemic, this NGT allowed for a socially-distanced, yet still organized and efficient consensus-building methodology.

Reaching consensus in this study was not difficult because the panelists have similar clinical practices and shared the same mission. They found relief knowing that they agreed and shared similar teaching methodologies. When their opinions varied, the discussion helped them understand each other's perspectives.

Existence of consensus does not mean these findings are hard and fast rules. Curriculum development is an ongoing process that needs constant reassessment and refinement to ensure goals and objectives are met.[13] The consensus findings established in this NGT are not the only items that should be considered when developing a military CRS curriculum. Instead, these items are meant to serve as a starting point for developing a comprehensive, current and successful curriculum.

Conclusions

This is the first study that attempted to obtain a consensus of experts to establish and describe essential elements of a military refractive surgery curriculum. It provides a standardized curriculum that may be used in all military refractive surgery training programs irrespective of the branch of service. A limitation of this study is the time constraint recommended in an NGT preventing the discussion of the sixth step in curriculum development. Evaluation and feedback is an important part of a curriculum and needs to be explored. Currently, there are no standardized or validated evaluation and feedback forms for military CRS curriculum. The pre-existing evaluation forms required by ACGME may not necessarily capture the CRS goals and objectives described in this study. Similar consensus-building techniques may be needed to compile any pre-existing evaluation and feedback tools and potentially validate them.

It is also worth noting that the primary researcher in this study is currently a director of one of the major military residency training programs which may have influenced the discussion topics and interpretation of findings. However, Potter et al argue that the NGT's inherently highly structured process minimizes researcher bias.[16] It is important to note that the investigators followed the NGT protocol and did not participate in idea sharing, discussion and voting. None of them discussed the details of the study with any of the panelists prior to the session. The primary investigator works in the same location as two of the panelists, but is not a supervisor for any of the panelists.

To address validity and acceptability of results, panelist experts were identified based on their current duty assignment, previous experience in both teaching and clinical practice, and

capability to enforce changes as suggested in prior NGT studies.[15] To enhance data trustworthiness and replicability, data analysis and interpretation were independently reviewed and verified by two co-investigators who do not have expertise in refractive surgery but are experts in academic research.

This study provides a starting point for program directors and curriculum developers to further enhance training standards and outcomes. Continued effort is needed to develop a more comprehensive curriculum that would include feedback and evaluation criteria for refractive surgery, not just in the military, but also in civilian refractive surgery training programs.

Table 1. Expert Panelists Summary

Service branch	Specialty	Current Position	Teaching experience
Navy	Cornea/Refractive	Refractive Surgery Center Director and Consultant	Military and civilian residents, civilian fellows
Army	Comprehensive Ophthalmologist	Residency Program Director	Military and civilian residents
Navy	Comprehensive Ophthalmologist	Refractive Surgery Center Director	Junior military staff after residency
Air Force	Cornea/Refractive	Refractive Surgery Center Director and Consultant	Military and civilian residents, civilian fellows
Army	Cornea/Refractive	Residency Program Director and Consultant	Military and civilian residents, civilian fellows
Air Force	Cornea/Refractive	Ophthalmology Consultant	Military and civilian residents, civilian fellows
Air Force	Cornea/Refractive	Refractive Surgery Center Director	Civilian residents
Army	Cornea/Refractive	Refractive Surgery Center Director	Military residents

Description of expert participants in this study.

Table 2. EDUCATIONAL STRATEGIES	
	Consensus
Tomography/Topograph guide	Absolutely needed
Staff demonstration of live surgery	Absolutely needed
Direct observation of preoperative evaluation	Absolutely needed
Direct surgical supervision	Absolutely needed
Direct supervision of postoperative care	Absolutely needed
Staff demonstration of preoperative evaluation	Absolutely needed
Lectures	Absolutely needed
Online certification modules	Absolutely needed
Online surgical videos	Absolutely needed
Wet lab (porcine eye model)	Absolutely needed
Small group discussion with peers & staff	Absolutely needed
Guided chart review of disqualified cases	Absolutely needed
Journal club	Would be nice to have
Review of resident surgical videos	Would be nice to have
Laser calibration	Would be nice to have
Important lecture topics	**Consensus**
Treatment options: PRK, LASIK, SMILE, ICL	Absolutely needed
Complications of each procedure	Absolutely needed
Tomography/Topography	Absolutely needed
Wavefront aberrometry	Absolutely needed
Different laser platforms	Would be nice to have

A list of educational strategies for CRS curriculum and expert participants' consensus vote.

Table 3. Items for Curriculum Implementation	
	Consensus
Faculty qualifications	
Minimum experience requirements	At least 1-2 years of clinical practice
	Have performed more than 30 procedures per laser platform
	Have performed more than 100 total procedures
Certified instructor	Would be nice to have
Cornea Fellowship	Would be nice to have
Refractive Surgery Fellowship	Would be nice to have
Support staff availability	Absolutely needed
Command support	Absolutely needed
Faculty availability	Absolutely needed
Training for staff members	Absolutely needed
Financial support for training and equipment	Absolutely needed
Physical space for training	Absolutely needed
Teaching Equipment	
Video recording	Absolutely needed
Wet lab materials	Absolutely needed
Other simulation models	Would be nice to have
Wi-Fi	Would be nice to have

A list of items related to CRS curriculum implementation and expert participants' consensus vote.

Supplemental Materials

Table S1. Summary of Goals and Objectives for Military CRS Curriculum

GOALS AND OBJECTIVES	Consensus
Broad program goal	Teach military ophthalmology residents at least LASIK[b] and PRK[c] across multiple platforms
% trainees to achieve laser certification during residency	Majority or >70% of trainees
Type/s of laser to get training and certification	Excimer and femtosecond lasers
Preoperative screening per trainee	At least 5 full evaluations (includes doing full eye exam, topography/tomography, aberrometry or other misc tests performed)
Preoperative evaluation and treatment planning per trainee	All patients treated with the resident must be consented, examined and evaluated by the resident under supervision of a staff surgeon.
Surgical minimum requirement per trainee	PRK 5-10, LASIK 21-25 (if SMILE[d] >25)
Important postoperative time points for trainees to see	PRK: POD[e] #1, POW[f] #1, POM[g] #1, LASIK: POD #1, POW #1
Postoperative check minimum number per trainee	PRK: no consensus, LASIK: 16-20

a: CRS, corneal laser refractive surgery; b: LASIK, laser-assisted in situ keratomileusis; c: PRK, photorefractive keratectomy; d: SMILE, small-incision lenticule extraction; e: POD, postoperative day; f: POW, postoperative week; g: POM, postoperative month

Chapter 3: Discussion

As mentioned above, more and more people are electing to have corneal laser refractive surgery to become more independent of eyeglasses and contact lenses. Hence, refractive surgery training is becoming more relevant as it is important that ophthalmologists know, not just the technical aspects of the procedure, but more importantly the management of potential complications. It is also known that different types of refractive surgery procedures may not be equally taught, since some procedures are technically more challenging than others. The minimum requirements set by ACGME and AUPO and the lack of standardized curriculum requirements among training programs may lead to unintentional bias towards teaching certain procedures that may not necessarily be the best procedure for every patient. Thus, it is important to develop a robust, comprehensive, standardized curriculum that may help all training programs produce competent refractive surgeons that would meet current demands of a growing body of refractive surgery patients.

Exposing residents to a few procedures as required by the ACGME without having specific guidelines on how to proceed with this training is not enough to give ophthalmology residents the experience to become competent refractive surgeons. A robust, comprehensive and standardized curriculum is needed to produce competent refractive surgeons. This consensus study serves as the first step in this process followed by implementation of these established guidelines.

Military Relevance

Corneal laser refractive surgery is considered an elective cosmetic procedure in the civilian sector. However, in the military, it is part of the combat readiness program. Warfighters have increased tactical advantage after refractive surgery as they are less dependent on corrective lenses that often get in their way during combat.[5] In 2010, Wright et al reported about 40-50% of USAF pilots and aircrew require corrective lenses to perform their duties. Their study also reported a prior survey that estimated about 50% of aircrew experience spontaneous loss of a lens and about half of those lost their lens in flight.[6] The important role of refractive surgery in helping service members decrease their vulnerability by achieving their best vision potential independent of glasses explains the need for a standardized and robust refractive surgery curriculum to consistently ensure the quality of refractive surgery training in the military. In addition, the goal of standardization directly echoes DHA's priority of achieving a highly reliable organization. This study established a consensus on the key components of a CRS curriculum that can be readily implemented by military CRS training programs.

Limitations and Future Research

The main limitation of this study is the time constraint, which prevented the discussion of evaluation and feedback tools that would be necessary to assess the achievement of curriculum goals and objectives. The exploration and validation of these tools would be the next step towards achieving a standardized CRS curriculum.

Another limitation is the possibility of researcher bias since the primary author is a military CRS trainer. However, this author did not serve as an expert participant in this study. The authors also

followed the main structure and carefully conducted each step of the NGT protocol, which should inherently minimize researcher bias.[16]

Although the basic concepts and curriculum development technique may be relevant to a broad audience including civilian training programs, the applications of this study may be limited to military ophthalmology residency training programs because the mission and goals of civilian and military training programs are often not similar. The goals and objectives may need to be adjusted when applied to more advanced trainees such as cornea fellows and general ophthalmologists to meet their clinical practice demands. Finally, the specifics of this curriculum may only be relevant to the present time. Therefore, the contents and objectives will need to be revisited and updated as advancements in technology and population demands evolve.

Conclusions

This project is the first attempt towards establishing a standardized CRS curriculum in the military using current practices and expert consensus. The study found consensus on specific goals, objectives, educational methods, and implementation strategies relevant to military CRS training. It serves as an initial step towards an expansive CRS curriculum that would be applicable, not only to military, but also to civilian CRS training programs, both at the present time and in the future.

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