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the most significant factors for differentiating latent keratoconus are differences in the parameters S-I in the 2–5 mm paracentral zone, SN-IT in the 2–5 mm paracentral zone and in the values of minimal corneal thickness. On the basis of the above-described results of this study, we can recommend that preoperative screening of patients before laser refractive corneal surgery includes not only on the standard diagnostic procedures (for example corneal topography) but also corneal imaging with the aid of AS OCT.

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REFRACTIVE ERRORS AMONG MEMBERS OF THE ARMED FORCES OF THE CZECH REPUBLIC

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The study is a publication of the partial results of the defense research project LASERVISION – influence of laser refractive eye surgery on quality of vision with the use of night vision goggles (NVG), which took place in the years 2018–2020 in cooperation with the Institute of Aviation Medicine Prague and the Central Military Hospital – Military University Hospital Prague. Targeted support was provided for the project by the Ministry of Defense on the basis of contract no. 1801 2 1270.

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SUMMARY

Objective: To evaluate the prevalence of refractive errors among members of the Armed Forces of the Czech Republic, to recommend a safe way of correcting refractive errors with regard to the specific needs of military personnel (especially members of combat units and flying personnel), and to propose a system for solving these errors in order to increase combat effectivity.
Methodology: Questionnaire to determine previous refractive surgery and spectacle correction wear. Measurement of refraction with a hand-held autorefractometer and evaluation of current visual acuity on ETDRS optotypes (Landolt rings).
Results: 259 servicemen (518 eyes) were investigated. The return rate of the questionnaires was 100%. The incidence of myopia greater than -0.75 D was 22% (113 eyes), myopia greater than -0.5 D 32% (166 eyes). The mean value of myopia was -0.78 D (SD ±0.6). Hypermetropia values ranged from +0.25 to +5.0 D. The mean value of hypermetropia was 0.63 D (SD ±0.7).
Astigmatism values ranged from -0.25 to -3.75. The mean value of astigmatism was -0.55 Dcyl (SD ±0.49). The average visual acuity was 84.1 letters ETDRS SD (±6.1), visual acuity worse than 80 letters was manifested by 23% of the members of the monitored group. 25 people (10%) had undergone laser refractive surgery. Visual acuity after laser refractive surgery was measured in 19 people (38 eyes). Mean uncorrected post-laser visual acuity was 83.87 (SD ±6.1) ETDRS letters. The mean follow-up period after laser refractive surgery was 6.78 (SD ±4.8) years.
Conclusion: Despite the initial selection of military personnel and entry limitations, the prevalence of refractive errors is comparable to the general population. However, in contrast with the general population, refractive errors larger than -3.0 D were not represented in the group. Due to the finding of insufficient correction of refractive errors, increased emphasis should be placed on identifying and regularly observing military personnel with refractive errors.
Key words: refractive errors, myopia, laser refractive surgery

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INTRODUCTION

The current developments of the armaments and gear used by the personnel of modern armed forces place ever greater demands on visual functions. Nevertheless, the proportion of refractive errors within the population is increasing [1–4]. Visual functions mediate approximately 80% of all received information about the surrounding environment. To a substantial degree, the quality of this information is dependent upon the visual acuity (VA) of the individual in question. Maximum uncorrected VA is limited to a marked extent by refractive error (myopia, hypermetropia and astigmatism). There are three possible means of correcting refractive errors – eyeglasses correction, contact lenses and refractive surgery. With reference to the existing armaments and equipment used, correction with eyeglasses (especially in combat units) is not entirely appropriate – eyeglasses may obstruct the use of ballistic helmets, chemical masks, ballistic goggles, night vision goggles (NVG) and gun scopes. Furthermore, upon the use of eyeglasses

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VA may also be reduced by environmental conditions (rain, rapid temperature changes, dusty environment), thereby restricting the soldier's capability for combat [5–7]. On first impressions, correction with contact lenses appears to be an advantage, since it is not affected by these limiting factors. However, a fundamental disadvantage is the increased demands for hygiene in care of contact lenses (risk of infection with the subsequent development of corneal ulcer, which may render the soldier permanently unfit for active service) [5,7]. This risk increases upon continuous field training, and especially during deployment in overseas operations (particularly in regions with a reduced or limited standard of hygiene and in dusty environments) [5,7]. With respect to the above-mentioned adverse factors influencing the use of eyeglasses and contact lenses by members of the armed forces, the current trend in modern armies is to improve uncorrected VA by means of laser surgery. Laser refractive operations have undergone advances over the last few decades, which enable the safe and effective improvement of uncorrected VA. Specialized programs for rectifying refractive errors by laser surgery are included as part of therapeutic preventive care for the armed forces in the USA and Australia, not only for members of combat units but also for high-performance pilots [7]. However, in order to create a similar program within the Armed Forces of the Czech Republic, it would first of all be necessary to assess the proportion of refractive errors within the population of military personnel in active service.

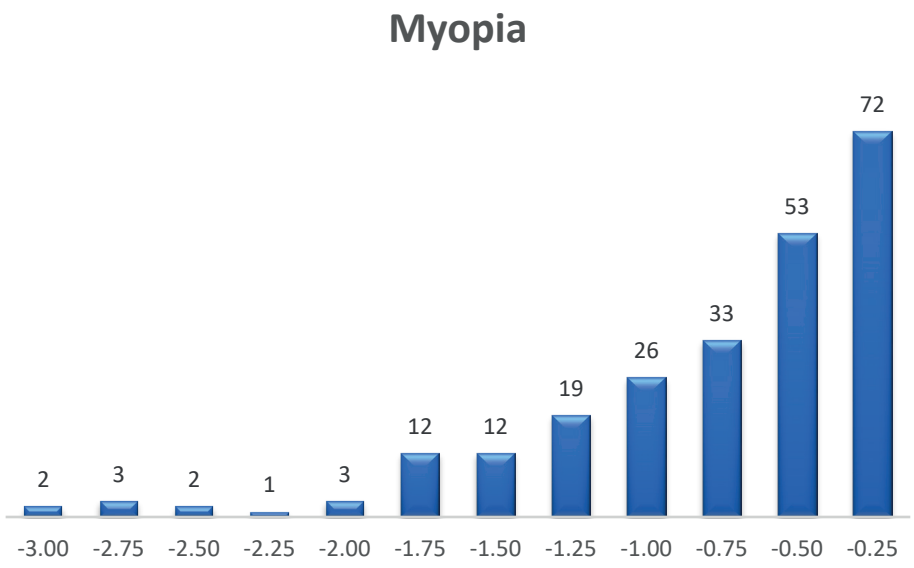
MATERIAL AND METHOD

Measurement of refractive status in the personnel of the Armed Forces of the Czech Republic was conducted at the hospital base in Těchonín on members of the guard platoon following their return from the Resolute Support mission in Afghanistan. All the returning personnel obtained and subsequently completed an anonymous questionnaire relating to refractive errors, their correction and any applicable previous refractive procedures. With reference to the individual approach, the return rate of the completed questionnaires was 100%. Subsequently, refraction was measured in all the individuals. The examination of refraction was conducted with the aid of the hand-held autorefractometer Handy Ref-K (NIDEK), without prior cycloplegia. The results of the measurement by autorefractometer were paired with the completed questionnaire. In 2019 the examination was supplemented by measurement of central VA on ETDRS optotypes (Landolt rings) at a distance of 4 meters (85 letters of ETDRS is equivalent to VA of 1.0). Uncorrected VA was measured, in the case of members using correction VA was then measured with the use of the existing correction. The aim was to determine current VA.

Within the LASERVISION project we measured the eyes of 259 professional soldiers (518 eyes). In all cases the soldiers were members of the guard platoon deployed in the protection of the military airbase at Bagram, Afghanistan. It was therefore important for all these subjects to have good VA, and optimally not to be dependent on correction with eyeglasses. The measurement was conducted in 3 sessions in the year 2018 (84 persons/168 eyes), and in 5 sessions in 2019 (175 persons/350 eyes). In accordance with the recommendation of the opponent board, in 2019 the questionnaire investigation and measurement of refraction was supplemented by measurement of VA (uncorrected or with current eyeglasses correction).

RESULTS

The incidence of myopia greater than -0.75 D was 22% (113 eyes), myopia greater than -0.5 D as high as 32%, 166 eyes. Values of myopia were within the range of -0.25 to -3.0 D. The mean value of myopia was -0.78 D (SD ±0.6). Graph 1. Values of hypermetropia were within the range of +0.25 to +5.0 D. The mean value of hypermetropia was 0.63 D (SD

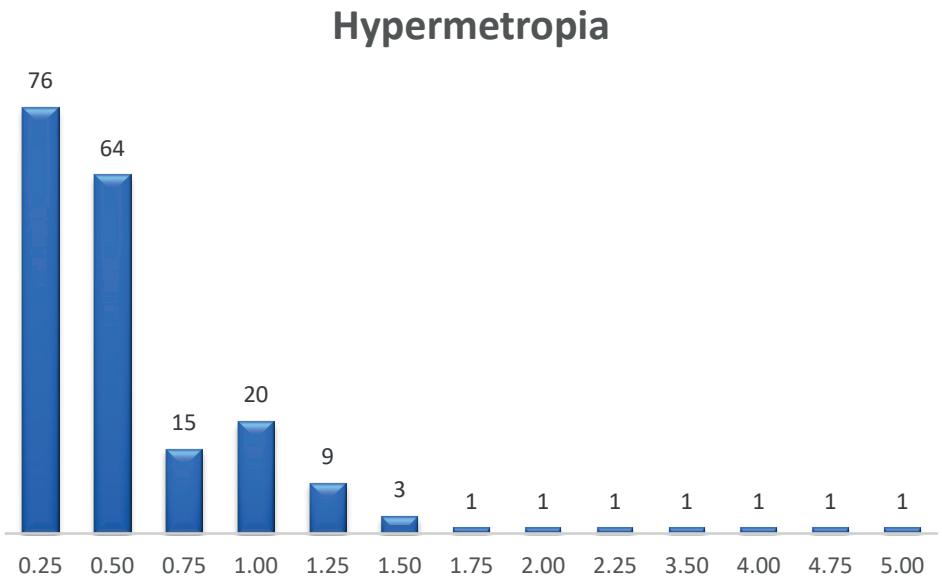


Graph 1. Frequency of the refractive error in the monitored group myopia (in diopters)

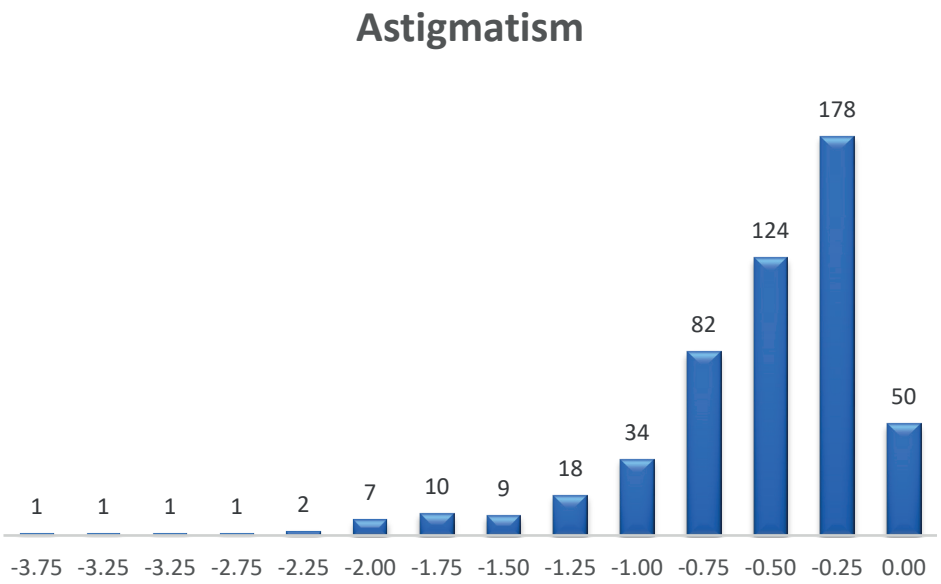
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±0.7). In 19 eyes we measured hypermetropia greater than 1 D (this was measured in younger individuals, in whom the measurement was conducted without cycloplegia, therefore the actual numbers and values may be higher), in 4 eyes we measured values greater than +3 D. Graph 2. Values of astigmatism were within the range of -0.25 to -3.75. The mean value of astigmatism was -0.55 Dcyl (SD ±0.5). We determined astigmatism greater than -0.75 Dcyl in 165 eyes (31%), while in 4 eyes the value was greater than -3 Dcyl, which may indicate the presence of keratoconus. Graph 3. VA worse than 80 letters of ETDRS was recorded in 23% of the members of the observed cohort. Out of the total number of 259 persons, 30 individuals had eyeglasses in their history or currently prescribed. Of these subjects, less than 30% (9 persons) had accurate correction, 8 had insufficient correction with central VA of less than 80 letters of ETDRS, 1 person did not use any correction whatsoever, while his CVA was only 35 letters of ETDRS. Mean VA was 84.1 letters of ETDRS (SD ±6.1). Graph 4. A total of 25 individuals had undergone laser refractive surgery (10%), mostly during their time of active service. Only 1 soldier had made use of the services of the refractive center at the Military University Hospital Prague. Graph 5.

AV after laser refractive surgery was measured in 19 persons (38 eyes). Mean uncorrected VA was 83.9 (SD ±6.1) ETDRS letters. Graph 6. VA of 85 ETDRS letters and better was measured in 63% of cases, 24 eyes. Graph 7. VA of 80 ETDRS letters and better was measured in 89%, 34 eyes. Graph 8. The mean period after laser refractive surgery was 6.8 (SD ±4.8) years.

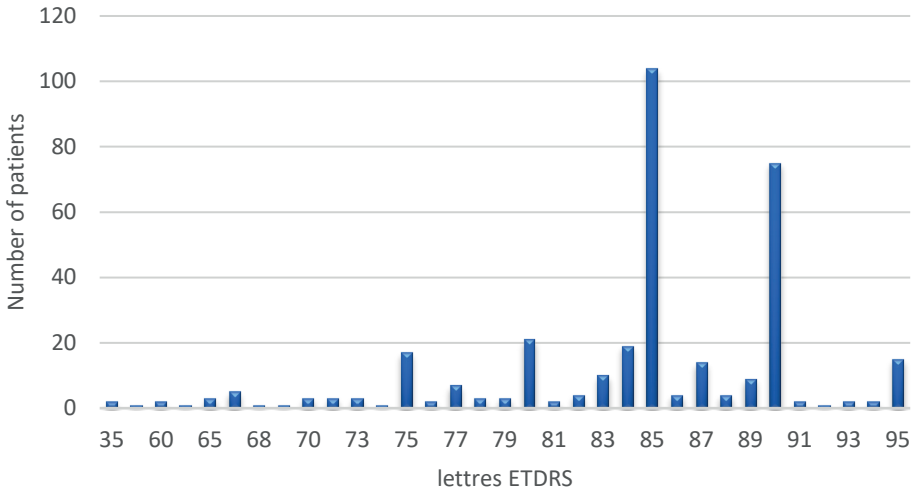


Graph 2. Frequency of the refractive error in the monitored group hypermetropia (in diopters)

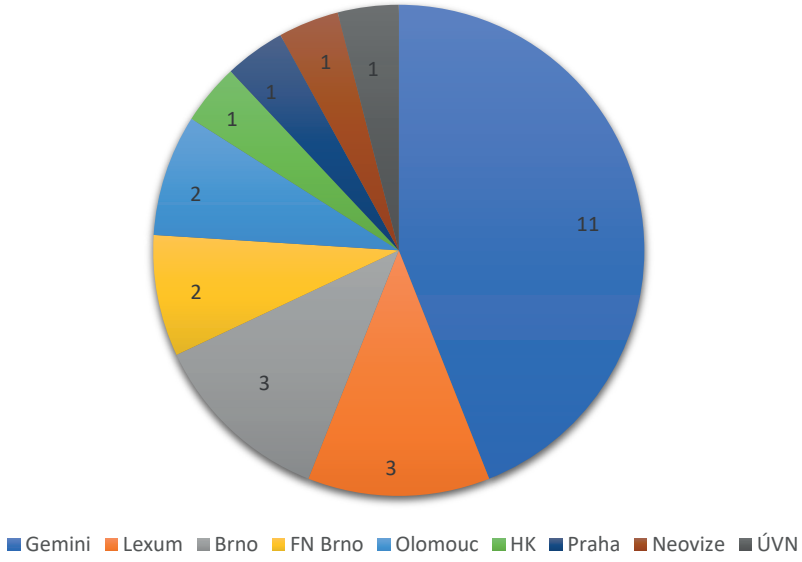


Graph 3. Frequency of the refractive error in the monitored group astigmatism (in diopters)

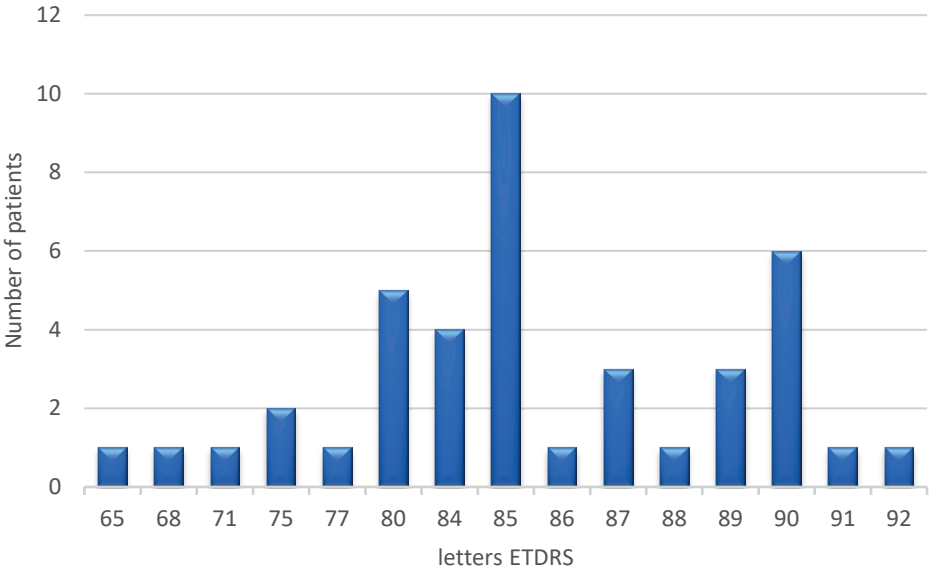
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Graph 4. Uncorrected visual acuity in military personnel (in letters ETDRS)



Graph 5. Number of military personnel undergoing the laser refractive surgery in different centers



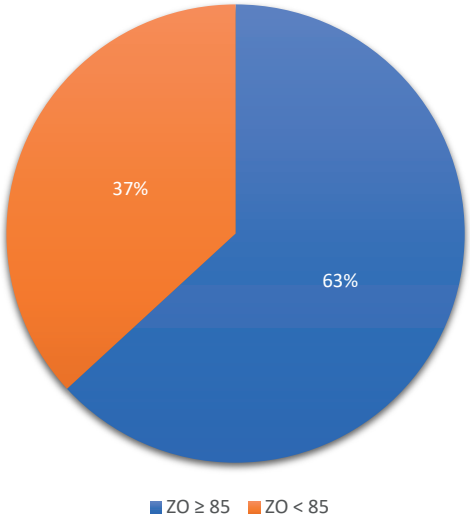
Graph 6. Uncorrected visual acuity in military personnel after the laser refractive surgery (in letters ETDRS)

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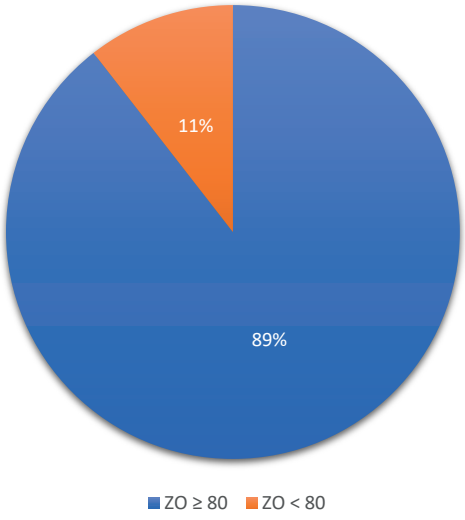
DISCUSSION

The incidence of myopia is stated at approximately 20% of the adult population [4]. The prevalence of the error is currently increasing, and in the countries of East Asia is approaching 80–90% [2,3]. With reference to the selection process of military personnel and the health limits stipulated by the assessment regulations (Decree no. 357/2016 Coll. Decree on Physical Capability for the Performance of Active Military Service), we expected a lower percentage representation of myopia among soldiers in the Army of the Czech Republic. However, the results of the LASERVISION project show that in spite of the selection process and the restrictions upon entry, the prevalence of the error is comparable with that in the general population: 22% of soldiers have myopia greater than -0.75 D, and as many as 32% have myopia greater than -0.5 D. Nevertheless, in contrast with the general population, there were no errors greater than -3.0 D in our cohort. The prevalence of high myopia (above -5.0 D) is 2.7% worldwide [4]. The absence of higher errors attests to the effectiveness of the selection process.

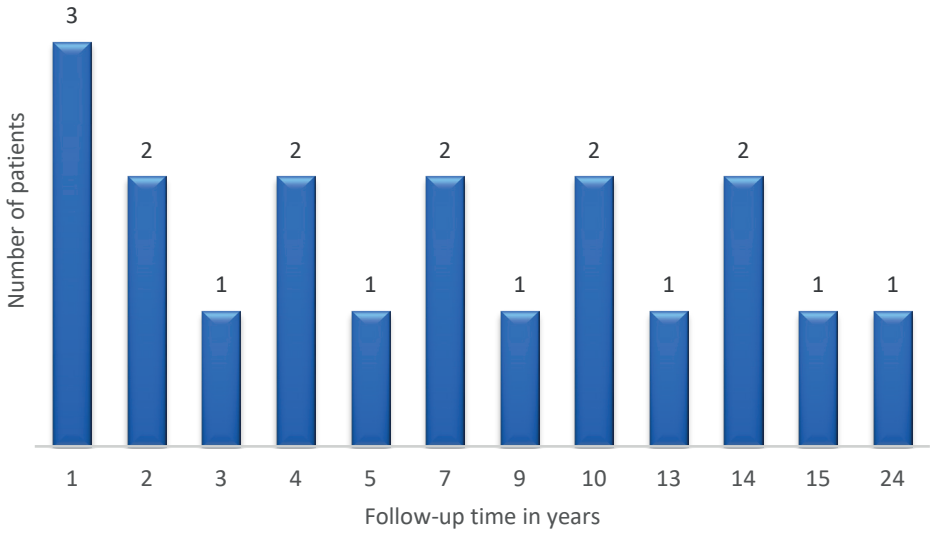
It ensues from the results of the measurements that 23% of individuals had VA worse than 80 letters of ETDRS. Visual acuity of 80 ETDRS letters may be sufficient under photopic testing conditions. In a combat situation at greater heights above sea level, in a dusty environment, in mesopic conditions and upon exposure to sustained acceleration during flight, though it may significantly impact upon the individual's capacity to differentiate [8,9]. Out of a total number of 259 subjects, 30 individuals had eyeglasses in their anamnesis or currently prescribed. Only less than 30% of soldiers had accurate correction with sufficient VA. The cohort included one of the commanders, who did not use correction with eyeglasses, and whose VA was a mere 35 ETDRS letters in both eyes (the refractive error in the right eye was -1.75 D/-0.25 Dcyl and in the left eye -1.25 D/-0.75 Dcyl). These deficiencies could di-



Graph 7. Uncorrected visual acuity in military personnel after the laser refractive surgery 85 letters ETDRS and greater



Graph 8. Uncorrected visual acuity in military personnel after the laser refractive surgery 80 letters ETDRS and greater



Graph 9. Follow-up time after the laser surgery (in years)

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rectly or indirectly endanger the performance of combat tasks and the safety of the soldiers, not only in extreme conditions in combat, but also during the training process in peacetime.

An interesting finding was the considerable number of subjects who had undergone laser refractive surgery for myopia. In total this concerned 25 individuals, which represents 10% of the military personnel. For the questionnaire investigation and measurement of the refractive status we intentionally selected members of combat units returning from combat deployment, in whom we expected that they would require good VA for the performance of their operational activities. This fact may therefore influence the relatively high representation of performed refractive operations. The actual proportion of soldiers who have undergone laser refractive surgery throughout the entire Armed Forces of the Czech Republic may be significantly lower. The fact that most of the procedures had been performed in private clinics (only 1 soldier had undergone surgery at the refractive center of the Military University Hospital Prague) indicates that there is insufficient monitoring of performed refractive operations in soldiers in active service.

In the case of 19 subjects, we succeeded in determining the time since their surgery from their history, and we also measured their VA after the surgery. The average time since laser refractive surgery was 6.8 years (SD ±4.8), in half of those observed a period of up to 5 years had elapsed, in a quarter only 2 years. Following the procedure, 63% of subjects had uncorrected VA of 85 ETDRS letters and better. VA of 80 ETDRS letters and better was present in 89% of individuals. The results are comparable with the study conducted by Godiwalla et al., who measured uncorrected CVA of 20/20 and better in 82% of subjects 13–14 months after surgery, while over a longer follow-up period (4–11 years) only 49% of subjects attained the same VA [10]. In 20-year observation, Cennamo et al. state uncorrected VA better than 20/25 in 37% of patients [11]. According to Dirani et al., long-term results are dependent on the severity of the preoperative refractive error – results in PRK and LASIK are better in the case of low and medium myopia. In a follow-up period of 2–13 years, 45% of patients with low and medium myopia attained refraction within the range of ±0.5 D after PRK, in comparison with only 25% of patients with severe myopia. In the case of LASIK this was 68% in the case of mild to medium myopia and 37% in the case of severe myopia. The long-term stability of refraction was better in the case of LASIK [12]. In a study conducted by Yamazaki et al., after a four-year follow-up period 82% of patients with a preoperative refractive error of up to -4 D attained uncorrected VA of 0.7 (70 ETDRS letters) after PRK, in comparison with only 77% in the group with a preoperative error of more than -4 D [13]. The results unequivocally attest to the benefit of laser refractive surgery for military personnel in active service, especially in the case of lower and medium myopia. Long-term stability and uncorrected VA are sufficient in ground military personnel (shorter time of active service in combat units, lower demands for central VA, price of training). In the case of aviation personnel, long-term stability is crucial (with regard to the length and financial demands of training). The results of the above studies have been directly projected into the new methodology, which specifies the assessment of aviation personnel according to Decree no. 282/1999 Coll. (On the Assessment of Physical Capability of Military Aviation Personnel) after refractive surgery: age limit for performance of surgery (min. 21 years), demonstrated preoperative stability of refractive error, requirement for limit of preoperative refractive error at -3 D, minimum corneal thickness after procedure of 450 um. With regard to the fact that only half of those observed attained VA of 1.0 (85 letters) in long-term observation following laser refractive surgery, and that mean refraction is greater than ±0.5 D, at present it is not possible to accept laser refractive surgery in applicants for study to qualify as a military pilot at the University of Defense.

CONCLUSION

The results of the project (questionnaire investigation and measurement of prevalence of refractive errors in the Armed Forces of the Czech Republic) can be used in the field of human resources, especially in the recruitment of new candidates. They can also serve to improve the quality of care of military personnel in active service and of active reservists in the case of diagnosis of refractive errors – regular checks, accurate correction, instruction on the mode of wearing correction and recommendation of the most appropriate form of correcting refractive errors (eyeglasses, contact lenses or refractive surgery) with reference to the service classification. A further step is to create a conception of an army refractive program, which shall enable control over the quality of performed refractive surgery procedures on members of the Armed Forces of the Czech Republic. This program can also function as a non-financial benefit for professional soldiers or a non-financial recruitment benefit. In addition, it can expand the numbers of suitable candidates for service in the Armed Forces of the Czech Republic and indirectly increase the combat capability of soldiers in active service and of active reservists by eliminating dependency on correction using eyeglasses.

A follow-up study shall assess the long-term stability of the results of refractive errors (evaluation of refraction status, uncorrected and best corrected VA, contrast sensitivity and corneal stability at an interval of 10–15 years after surgery). The demonstration of good long-term stability of refraction and sufficiently good uncorrected VA would enable a review of the procedure for assessing military aviation personnel during entrance examinations, and use of the results in the creation of a new regulation.

Used regulations:

Decree of the Ministry of Defense 282/1999 Coll. On the Assessment of Physical Capability of Military Aviation Personnel

Decree of the Ministry of Defense 357/2016 Coll. Decree on Physical Capability for the Performance of Active Military Service

Bulletin of the Ministry of Defense no. 4 of 5 March 2021,