New Methods of Treatment in Presbyopia

Nowości w leczeniu starczowzroczności

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Abstract

Age-related vision impairment (presbyopia) is a consequence of a physiological process, determined by multiple factors, involving gradual loss of accommodation potential of the eye due to lens sclerotization and loss of elasticity [1, 2]. It affects most subjects above 45 years of age as an inevitable consequence of aging. Increasing life expectancy in developed countries has resulted in rising demand for correction of presbyopia (Adv Clin Exp Med 2010, 19, 3, 405–409).

Key words: presbyopia, monovision, aspherical lenses, termokeratoplasty, diffraction lenses.

Corrective Glasses

Glasses have been the oldest method, still used for correction of physiological loss of the eye accommodation ability. However, their use is associated with certain limitations. They are easy to use and commonly accepted by the majority of patients, but they pose some important problems. First, it is necessary for the patients to have two pairs of glasses – for long and short distance, except for those who need glasses for reading only, or subjects with myopia, who need glasses for looking at long distance only [3]. Bi- or trifocal lenses eliminate the need to have two pairs of glasses and are especially useful for patients who have to change the looking distance frequently. However, it should be remembered that their function enables to observe objects from specific distances. Limitations emerge in some atypical conditions, requiring observation of objects at distances other than normally, which may not only cause discomfort to the patients, but also compromise their safety. Therefore, the necessity for the patient to adapt to such lenses and to cope with atypical situations imposes certain limitations on the applicability of this method. Progressive lenses, characterized by gradual change of the focal length, are another achievement in presbyopia correction. The lack of visible borderline between the area designed for looking at long distance and that designed for reading is not only an aesthetic asset, but also makes it easier for the patient to adapt to variable environmen-
tal conditions. Spheric aberrations, impairing the acuity of vision in the peripheral parts of the lens, are a disadvantage of progressive lenses difficult to accept for some patients [3, 4].

**Contact Lenses**

Indications and contraindications for the use of contact lenses by presbyopic patients are similar to those applicable to young patients with refraction abnormalities.

However, an elderly patient is generally more demanding than a young one. Problems with finding suitable lenses result from age-related anatomical and physiological changes in the eye. Factors limiting the possibility of using contact lenses include also lack of proper hygiene, chronic pathologic or degenerative conditions affecting the ocular surface, impaired function of hands, as well as financial situation of the patient. On the other hand, presbyopic patients have less sensitive palpebral margins and cornea, which facilitates the adaptation process [5]. Correction of presbyopia with contact lenses includes: selection of appropriate lenses for distance and glasses for reading, monovision, bifocal alternative or simultaneous lenses, as well as progressive lenses. Selection of contact lenses for looking at longer distances with additional glasses for reading is a simple and effective method of correction, which is, however, not satisfactory for patients who wish to eliminate the need for glasses completely [6]. Monovision involves correction of one eye, usually the leading one, for long distances, and the other for short distances, and is appreciated by many patients as a convenient and economical method. Monovision takes advantage of the ability of the nervous system to perceive clear images and suppress images not focused on the retina, but it abolishes stereoscopic vision, thus reducing the perception of contrast and depth, which can be difficult to accept for many patients [6, 7]. Simultaneous perception of both distant and close objects with both eyes is possible for presbyopic patients owing to bifocal or progressive lenses. The short-distance element in bi- and multifocal lenses can be central or peripheral, arranged concentrically (concentric ring lenses) or at 1/3 of the inferior portion of the lens (segment lenses) [3]. Glasses with progressive lenses can be replaced by aspherical contact lenses with variable focal length, providing a possibility of gradual transition from correction of long-distance vision to correction of short-distance vision. Looking at a specific distance, the patient uses only a small area of the lens, which is a shortcoming of this method [6]. Taking advantage of the phenomenon of diffraction in lens production to obtain a second image was a revolutionary idea. The posterior surface of diffraction lenses has incisions, which filled with tears increase deflection of light. The limitations for their use includes the necessity of tight fitting and decrease of the patient’s sensitivity to contrasts.

**Surgery**

Intensive development of surgery in the last years has resulted in new options for presbyopia correction. There are currently three groups of surgical procedures: those performed on the cornea, sclera, and intraocular surgery [7].

**Corneal Surgery**

The excimer laser, used for correction of myopia, has been applied also in presbyopic patients. In patients with normal vision, who tolerate monovision well, laser correction of corneal shape can cause mild shortsightedness, allowing to see clearly at short distance, while leaving the other eye unaffected. In contrast, myopic patients undergo complete correction of the defect in one eye, leaving ca. 2–3 spheric dioptries in the other one. Qualification of the patients for refractive laser surgery procedures aimed at creating monovision should take into consideration their motivations, psychological aspects and personality, remembering that they must adapt to the new situation, which, however, is often poorly accepted.

The excimer laser makes it also possible to apply multifocal corneal ablation technique. It involves appropriate modeling of the central and peripheral zone of the cornea, according to the size of the pupil, which creates aspheric curvature improving the visual depth and acuity [4]. A so-called pseudoaccomodation phenomenon is achieved [9]. Short-distance vision is improved owing to simultaneous perception of images received from various foci by the retina, resulting in subjective increase of accommodation amplitude. It increases the visual depth and acuity despite unchanged power of the optic lens [9]. The multifocal corneal ablation method yields good results, although usually good long-distance vision is obtained with compromised short-distance one, or vice versa [8].

**Intracorneal Implants**

The aim of intracorneal implants is to improve the sight by changing the shape of the cornea. The surgical technique involves excision of a small
corneal flap with microkeratome, followed by intracorneal implantation of an aspheric ring. Intracorneal implants can be used in patients with hypermetropia ranging from 1.0 to 6 Diopters and astigmatism not exceeding 1.0 D. Severe astigmatism, myopia and hypermetropia exceeding 6.0 D, as well as lens opacification, keratoconus and dry eye syndrome, are currently regarded as contraindications for the procedure. An advantage of this method is its reversibility. In case of failure or problems with adaptation of the patient, the implant can be removed. Intracorneal implants can be also used in patients who previously underwent refractive procedures. As the experience associated with this method is not extensive yet, some of the potential complications may be unknown [10]. The known ones include changes in corneal metabolism, opacification, wound healing complications and displacement of the implant, which can require its correction or removal. In 2008, Yilmaz et al. [11] presented the results of a study assessing the efficacy of ACI-7000 intracorneal implants in improving visual depth in normovision patients with presbyopia. The study was carried out in a group of 39 patients, some of whom had previously undergone LASIK correction procedures, who received intracorneal implants and were followed up for a year. In 3 patients, the implants were removed, which did not affect the corrected visual acuity. In the remaining 36 subjects, long-distance vision acuity did not change, whereas the mean non-corrected short-distance vision acuity improved significantly within the year following the procedure. In all eyes with implants, non-corrected short-distance vision acuity was J3 or better, and in 85.3% of cases – J1 or better. The above results suggest that intracorneal implants are an effective and safe method of presbyopia correction, which, however, still requires confirmation by long-term studies, allowing to assess the distant complications associated with this technique.

**Thermokeratoplasty**

Thermokeratoplasty was first described by Lans in 1898. It involves elevation of the corneal surface by means of head radiation in order to correct hypermetropia. Initially, a hot wire was used, which was then replaced by a nickel probe. However, this technique led to complications such as corneal burns, scars, endothelial damage and defect regression [8]. Corneal surgery utilizing holmium:YAG laser (laser thermokeratoplasty – LTK) involves thermal modification of collagen fibers and is another variant of this procedure. Contact and non-contact versions of the method are distinguished (temperature 58–75° or 23–40°, respectively), involving 1 to 3 circular applications in 8 points for each circle, which leads to changes in collagen fibers of the corneal stroma [7]. Another modification of the procedure is diode laser thermokeratoplasty (DTK). The foci are larger here and penetrate deeper than in case of LTK [4].

Conductive termokeratoplasty (CK) is a new method utilizing radio waves of 350 Hz frequency, which alter the shape of the cornea by homogeneous increase in temperature inside, which causes the collagen to shrink and to form cylindrical foci deep in the corneal matter [8]. The method, described for the first time in 1993 by Mendez et al., has been approved by US Food and Drug Administration (FDA) for the treatment of mild and moderate hypermetropia in patients above 40 years of age with corneal thickness exceeding 560 μm [7, 8]. CK, like other types of thermokeratoplasty, uses a circular pattern of heat application – 8 points in 1–3 circles of 6, 7 or 8 mm diameter [7]. It causes flattening of the peripheral part of the cornea and elevation of its central part. The magnitude of correction depends on the number of heat applications: the smaller the circle diameter, the better the effect [4]. Presbyopia can be corrected with CK in two ways: by creating monovision, inducing mild myopia (–1 to –1.5 D) in one eye (for short distance viewing) and plano in the other (for long distance viewing, or by so-called “mixed vision” and multifocal effect, similar to that obtained with excimer laser corneal ablation technique. CK elevates the central part of the cornea by the complex of circular and radial vectors of the forces applied. This creates in the cornea many different foci, which allow to improve visual depth, and, consequently, to restore partially short-distance vision [8]. The procedure involves alteration of corneal structure beyond the visual axis, which seems to be safer than refractive corneal procedures. Besides, it does not require incisions made to form the corneal flap, which allows to avoid healing complications. Microscopic studies indicate no clinically perceptible changes in the corneal stroma, including no partial corneal opacification in 98% of eyes 1 month after CK. The main complication of the procedure is astigmatism. One year after the procedure, progression of astigmatism by 1 D or more was observed in over 10% of eyes [7]. However, this method can be used to correct hypermetropia up to 3 D only.

**Scleral Surgery**

Procedures performed on the sclera with the aim of presbyopia correction include radial incisions of the sclera and introduction of intrascleral
implants [8]. Both these methods are intended to increase the scleral circumference. The scientific basis for this method is Schachar’s theory, according to which during accommodation the ciliary muscle, connected to the sclera, contracts, causing an increase and not a decrease (as in Helmholtz’s theory) of the tensile forces acting on the ciliary margin. The volume of the lens increases with age, which results in relaxation of the ciliary ligaments and deterioration of accommodation. Extending the sclera, and consequently increasing the diameter of the ciliary body, is expected to restore appropriate relations between the ciliary body and the lens and the accommodation potential. (It is currently acknowledged that Helmholtz’s theory is closer to the actual accommodation mechanism in humans – author’s comment). Radial incisions of the sclera, first proposed by Thornton, performed at the level of the ciliary muscles, are intended to change the anatomic conditions, thus restoring lens accommodation. They reach the depth of 95% of the scleral thickness, i.e. ca. 600 μm [15, 16]. Fukasaku and Marron reported good preliminary results of this method, with mean accommodation amplitude increase of ca. 2.2 D. However, the effect was found to be short-lasting, because one year after the procedure the amplitude increase was only 0.8 D [15].

Another method introduced by Schachar was surgical correction involving application of intracocular implants positioned at the level of the ciliary body (scleral expansion bands – SEB). The aim of this technique was to increase the distance between the ciliary muscle and the lens equator, which should theoretically allow more intensive work of the muscle in the posterior chamber. SEB are a development of an earlier concept involving intrascleral implantation of hard rings. However, that method was abandoned because of long-term complications such as ischemia of the anterior eye segment. Hard rings have been replaced by silicone implants positioned at the level of the ciliary body after previous formation of 4 radial incisions. They are supposed to stretch the sclera, and, consequently, to pull the adjacent ciliary muscle, thus restoring appropriate tone of Zinn’s ligaments [12, 13]. Despite considerable interest aroused by this theory, it failed to find a significant confirmation in practice. Malecaze et al. studied a group of 6 patients, 4 of whom underwent implantation of SEB into one eye, and 2 into both eyes. In all of these patients, there were no changes in long-distance vision. However, short-distance vision and subjective perception of accommodation amplitude was improved only in three eyes. In the remaining five, no changes due to the implant were observed [12]. Similar results were obtained by Mathews, who investigated the accommodation amplitude before and after the application of this method in 3 subjects [13]. Although results suggesting the accuracy of Schachar’s theory and the surgical methods based on it can be found in the literature, e.g. in a study by Oazi et al., who confirmed the effectiveness of surgical treatment in 50% of the studied presbyopic patients [14], the method has not been accepted for widespread use. Long-term studies indicate lack of sustained effects and unpredictability of the procedures, as well as lack of satisfaction of the patients operated on with this technique. An alternative to radial scleral incisions is Laser Presbyopia Reversal (LAPR) where 8 incisions of ca. 2.5 mm length and 400–500 μm depth are preformed with a laser. Owing to the use of laser, blood vessel cauterization is obtained at the same time, the incisions are more precise and regression slower than in case of traditional surgery [4, 7].

Intraocular Surgery

Modern intraocular surgery allows implantation of two lens types: multifocal and accommodation ones, for correction of presbyopia. Multifocal, silicone lens implants ARRAY (AMO) have been most commonly used recently. Their optic part contains five alternating optic spheres in the form of rings with different dioptic power. The central zone is designed for long-distance vision, whereas zones 2 and 4 have additional power appropriate for short-distance vision. Intermediate distance vision is possible owing to aspheric, mild transition between the zones. Because of vision disturbances reported by the patients (dazzle, light-near dissociation) the models more frequently used now include an acrylic ReZoom lense, representing a new generation of lenses with altered proportions of optic zones and a diffraction lense – ReSTOR (Alcon), making use of diffractive apodization phenomenon, providing even distribution of light for long and short distances, no dependence on the pupil size, as well as reduction of dazzle and “halo” effect.

The second group of lenses included accommodation lenses, mimicking the accommodation capability of the eye with the implant. This effect is achieved by mobility of the optic segment of the lens with contractions and relaxation of the ciliary muscle and, indirectly, as a result of pressure on the lens exerted by the vitreous. Two types of accommodation lenses: CristaLens and 1CU are currently available [4, 7].

Conclusions

There are currently numerous methods allowing to correct presbyopia, but each of them has some disadvantages. The patients’ require-
ments with respect to this problem are varied. The wide spectrum of available methods indicates, on the one hand, the lack of a perfect solution for presbyopia correction, and on the other makes it possible to select an appropriate method suited best to the patient’s preferences. Because of life span increase, the subjects affected with presbyopia are often still working and active. Therefore, rising social demand prompts successful research aimed at the development of new, improved methods. The use of appropriate corrective glasses still remains the most popular method, mainly because of non-invasive character of this solution. Contact lenses can be recommended primarily to patients who have used them previously, because they are rarely tolerated well when they are first fitted after 45 years of age and when long-distance vision is good without correction. The surgical procedures performed on the sclera, based on Schachar’s theory, failed to meet the expectations associated with that technique. The results of studies carried out in groups of patients who underwent corneal procedures, such as thermokeratoplasty, also remain disputable. On the other hand, as far as artificial lens implantation procedures are concerned, considerable progress in cataract surgery seen in the last two decades, including improvement of safety of these procedures, practically complete reduction of postoperative astigmatism and high predictability of postoperative visual acuity, makes this method worth recommending to patients who wish to get rid of glasses for reading, and especially to those with defects such as hypermetropia or myopia. Additionally, bifocal toric lenses allowing patients with presbyopia and astigmatism to eliminate to a large extent the use of glasses have become available recently.

References

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