OPTOMETRIC CLINICAL PRACTICE GUIDELINE
CARE OF THE PATIENT WITH MYOPIA

Reference Guide for Clinicians

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NOTE: Clinicians should not rely on this Clinical Guideline alone for patient care and management. Refer to the listed references and other sources for a more detailed analysis and discussion of research and patient care information. The information in the Guideline is current as of the date of publication. It will be reviewed periodically and revised as needed.

INTRODUCTION

Optometrists, through their clinical education, training, experience, and broad geographic distribution, have the means to provide effective primary eye and vision care for a significant portion of the American public and are often the first health care practitioners to diagnose patients with myopia.

This Optometric Clinical Practice Guideline for the Care of the Patient with Myopia describes appropriate examination and treatment procedures for myopia and contains recommendations for diagnosis and management of myopia. This Guideline will assist optometrists in achieving the following goals:

- Accurately diagnose the different types of myopia

- Improve the quality of care rendered to patients with myopia

- Inform and educate parents, patients, and other health care practitioners about the options of correction, control, or reduction of myopia

- Decrease visual morbidity related to higher degrees of myopia.

I.   STATEMENT OF THE PROBLEM

Myopia is the refractive anomaly of the eye in which the conjugate focus of the retina is at some finite

point in front of the eye, when the eye is not accommodating. It can also be described as the refractive

condition in which parallel light rays from an object at optical infinity are focused by the eye in front of the

retina, with accommodation relaxed. Myopia is derived from the term "muopia" which, in Greek, means to

close the eyes. It manifests itself as blurred distance vision, hence, the popular term "nearsightedness."

Clear distance vision can be restored by the application of the proper minus power (concave) spectacle

or contact lenses or corneal modification procedures in which corneal refractive power is decreased. In

some cases of pseudomyopia, unaided distance vision can be improved with vision therapy.

Myopia is a highly significant problem, not only because of its high prevalence, but also because it can

contribute to visual morbidity and increase the risk for vision-threatening conditions (e.g., retinal breaks

and detachment, glaucoma). Because myopia is associated with reduced distance vision without optical

correction, it can be a limiting factor in occupational choices. Uncorrected myopia prevents the individual

from seeing distant objects clearly. In addition, the posterior segment changes in the myopic eye place it

at risk for the development of other ocular conditions.

A.   Description and Classification of Myopia

Various classification systems have been described for myopia (Table 1).[1] This Guideline uses a

classification by clinical entity: simple myopia, nocturnal myopia, pseudomyopia, degenerative myopia,

and induced (acquired) myopia.[2] Other systems classify myopia by degree (i.e., low, medium, or high) or

by age of onset (i.e., congenital, youth-onset, early adult-onset, late adult-onset).[1]

There is a somewhat different diagnosis and treatment strategy for each type of myopia. Simple myopia

and nocturnal myopia may be viewed as physiologic forms of myopia because the only deviation from

normal structure and function is the need for minus power lenses for normal distance visual acuity.

Degenerative myopia, also called pathological myopia, is due to the development of structural defects in

the posterior segment of the eye. Induced myopia may be viewed as a secondary myopia that is

pathologic in nature, i.e., some external agent or alteration of normal physiological function has induced

the myopia, which is often temporary. (See Appendix Figure 3 for ICD-9-CM classification codes for

myopia.)

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Insert Table 1 here

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1.   Simple Myopia

The refractive status of the eye with simple myopia is dependent on the optical power of the cornea and

the crystalline lens, and the axial length. In emmetropic eyes, axial length and optical power are inversely

correlated.[3-9] An eye with greater than average optical power can be emmetropic if it is sufficiently

shorter than average, as can an eye with less than average optical power if it is sufficiently longer than

average.

An eye with simple myopia is an otherwise normal eye that is either too long for its optical power or, less

commonly, too optically powerful for its axial length. Simple myopia, which is much more common than

the other types of myopia, is generally less than 6 diopters (D); in many patients it is less than 4 or 5 D.

Astigmatism may occur in conjunction with simple myopia. Terms used to describe the combination of

myopia and astigmatism include astigmatic myopia, simple myopic astigmatism (when one principal

meridian of an eye is emmetropic and the other is myopic), and compound myopic astigmatism (when

both principal meridians are myopic). When the degree of myopia is unequal in the two eyes, the

condition is called anisometropic myopia (anisomyopia); when one eye is emmetropic and the other is

myopic, the condition is known as simple myopic anisometropia. Although it is not at all uncommon for the degree of myopia to differ between the two eyes, anisometropia may not become clinically significant until the difference between the two eyes reaches about 1 D.

2.   Nocturnal Myopia

Occurring only in dim illumination, nocturnal or night myopia is due primarily to increased accommodative response associated with low levels of light.[10-13] Because there is insufficient contrast for an adequate accommodative stimulus, the eye assumes the intermediate dark focus accommodative position rather than focusing for infinity.

3.   Pseudomyopia

Pseudomyopia is the result of an increase in ocular refractive power due to overstimulation of the eye's accommodative mechanism or ciliary spasm.[2,14,15] The condition is so named because the patient only appears to have myopia due to an inappropriate accommodative response.

4.   Degenerative Myopia

A high degree of myopia associated with degenerative changes in the posterior segment of the eye is known as degenerative or pathological myopia.[2,16] The degenerative changes can result in abnormal visual function, such as a decrease in best corrected visual acuity or changes in visual fields. Sequelae such as retinal detachment and glaucoma are relatively common.

5. Induced Myopia

Induced or acquired myopia is the result of exposure to various pharmaceutical agents, variation in blood sugar levels, nuclear sclerosis of the crystalline lens, or other anomalous conditions.[17] This myopia is often temporary and reversible.

B. Epidemiology of Myopia

1. Prevalence and Incidence

The prevalence of myopia varies with age and other factors. When examined without the aid of cycloplegic agents, a significant number of infants are found to have some degree of myopia.[18,19] Their myopia tends to decrease, and most such infants reach emmetropia by 2-3 years of age. The prevalence of myopia is high in premature infants.[20,21]

Myopia of at least 0.50 D has a lower prevalence (< 5%) in the 5-year-old population than in any other age group.[22,23] The prevalence of myopia increases in school-age and young adult cohorts, reaching 20-25 percent in the mid to late teenage population and 25-35 percent in young adults in the United States and developed countries.[22-30] It is reported to be higher in some areas of Asia.[31] The prevalence of myopia declines somewhat in the population over age 45 years, reaching about 20 percent in 65-year olds,[25,30,32] and decreasing to as low as 14 percent of persons in their seventies.[33] Reviews of the extensive literature on myopia identify some factors associated with prevalence.[34-39] Some studies have found a slightly higher prevalence of myopia in females than in males. The prevalence of myopia increases with income level and educational attainment, and it is higher among persons who work in occupations requiring a great deal of near work.

2.   Risk Factors

An important risk factor for the development of simple myopia is a family history of myopia.[19,40-43] Studies have shown a 33-60 percent prevalence of myopia in children whose parents both have myopia. In children who have one parent with myopia, the prevalence was 23-40 percent. Most studies found that when neither parent has myopia, only 6-15 percent of the children were myopic. A difference in the prevalence of myopia as a function of parental history exists even for children in their first few years of school.[44]

Myopia that is revealed by noncycloplegic retinoscopy in infancy and subsequently decreases to emmetropia before the child enters school appears to be a risk factor for the development of myopia during childhood.[19] One analysis suggests that refractive error at school entry is a better predictor of who will become myopic in childhood than either parental history of myopia or the presence of myopia in infancy.[45] Both children[46-48] and young adults[49-52] with refractive errors in the range of emmetropia to about 0.50 D of hyperopia are more likely to become myopic than individuals of the same age who have hyperopia greater than about 0.50 D. Moreover, the risk for myopia is higher in children who have against-the-rule astigmatism.[45]

Some characteristics of the ocular accommodative and vergence systems may be risk factors for myopia development. These include esophoria at near, low positive relative accommodation, and a more convergent position of the midpoint between the near base-in and base-out fusional vergence ranges.[53-56] Young adults with myopia have a more distant dark focus of accommodation than young adults with emmetropia or hyperopia.[57-59] Accommodative response to stimuli from a closer viewing distance or from added minus lens power is lower in persons with myopia and in children who are actively progressing toward more severe myopia than in persons with emmetropia or hyperopia.[60-63] Decreased accommodative response for nearpoint viewing detectable by more plus lens power on dynamic retinoscopy or the binocular cross cylinder test is a risk factor for myopia that is consistent with

contemporary theories of the development of myopia. The theories are based on studies of experimental animal models in which retinal image defocus can result in myopia.[64-69]

Doing a substantial amount of near work on a regular basis can increase the risk for myopia. Myopia is associated with greater time spent reading and doing near work, better reading test scores, more years of education, occupations that require a great deal of near work, and greater academic ability.[26,34,37,70-76]

Steeper corneal curvature and a ratio of axial length to corneal radius that is greater than 3.00 may also be risk factors.[47,77] In children, conditions that prevent normal ocular image formation (e.g., eyelid hemangiomas, neonatal eyelid closure, corneal opacity, retrolental fibroplasia associated with retinopathy of prematurity, and vitreous hemorrhage) often result in myopia.[20,78-84] These relatively severe disruptions result in a high degree of myopia, which is usually pathological.

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Insert Table 2 here

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C.   Clinical Background of Myopia

1.   Natural History

a.   Simple Myopia

Myopia that develops in childhood is often called youth- or juvenile-onset myopia.[1] Once simple myopia appears in a child, it almost always increases in severity.[85-87] Studies have found that the rates of progression of childhood myopia range from 0 to over 1.00 D per year, but that most progression is in the

range of 0.3-0.5 D per year.[88] The progression of childhood myopia commonly stops or slows down in the middle to late teenage years, sooner for girls than for boys.[89]

Progression of simple myopia can occur in adults who had myopia in childhood or in young adults with adult-onset myopia. Early adult-onset myopia appears between ages 20 and 40; late adult-onset myopia appears after age 40.[1] The rates of progression of myopia during young adulthood are generally lower than the rates of progression of childhood myopia.[51,90-94] Myopia usually decreases in severity beginning at about age 45.[32,33,86]

Although the precise etiology of simple myopia is unknown, both inheritance and environmental factors play significant roles. The strong association of myopia and near work[34,36,37,72-74,95,96] suggests near work as an etiological factor. Animal studies have shown that a defocus of retinal imagery induces myopia by stimulating an elongation of the vitreous chamber, moving the retina behind the focal plane.[66-69] Diet has sometimes been suggested to be a factor, but supporting evidence is not available.[2]

b.   Nocturnal Myopia

Occurring under conditions of darkness or very dim illumination, nocturnal myopia is due largely or entirely to an increase in accommodation associated with the decreased accommodative cues in darkness. The accommodative dark focus appears to be relatively stable, at least over a period of days.[97,98]

c.   Pseudomyopia

Pseudomyopia is generally encountered in younger patients performing excessive close work. Sustained or excessive near demands result in hypertonicity of the ciliary body such that an emmetropic or slightly hyperopic patient clinically appears to be myopic or a myopic patient appears to be more so. In

psychogenic accommodative spasm, psychological influences can produce spasm of the near reflex.[17] There do not appear to be any data on changes in pseudomyopia over time. Presumably, the condition is longstanding.

d.   Degenerative Myopia

Enlargement of the eye in degenerative myopia may affect the appearance of the optic nerve. The retina is temporarily stretched away from the optic nerve (myopic conus). The peripheral retina is also affected, producing characteristic changes of degenerative myopia. Lattice degeneration increases in prevalence from less than 1 percent in eyes with 22-mm axial lengths to approximately 16 percent in eyes with axial lengths of at least 30 mm.[99] As the eye enlarges, the retinal pigment epithelium thins,[100] resulting in a tessellated (checkered) appearance of the fundus and increased visibility of the choroidal vasculature. Posterior staphyloma can also develop as the eye enlarges.[101] Stretching and thinning of the choroid can result in decreased choroidal circulation and choroidal neovascularization.[102] Severe congenital myopia during infancy typically becomes degenerative myopia.

e.   Induced Myopia

The natural history of induced myopia depends upon the initiating condition or agent. A refractive shift toward myopia after about age 60 is usually associated with the development of nuclear sclerosis of the crystalline lens,[103] and thus is a form of induced myopia.

Table 3 lists possible etiologic factors for the development of each type of myopia.

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2. Common Signs, Symptoms, and Complications

The most common symptom associated with uncorrected myopia is blurred distance vision. In simple myopia and degenerative myopia, the distance blur is constant. In nocturnal myopia, distance vision is blurred only in dim illumination or in dark conditions. In pseudomyopia, the blurred distance vision may be constant or intermittent with greater distance blur occurring after near work. Blurred distance vision in induced myopia can vary from transient (lasting a few hours) to constant, depending upon the particular agent or condition causing it.

With the exception of pseudomyopia and some forms of induced myopia, asthenopic symptoms are not characteristic of myopia. If asthenopia is present in a patient with myopia, it is usually due to some other cause, such as astigmatism, anisometropia, an accommodative dysfunction, or to a vergence disorder. Children with simple myopia are often unaware that they have reduced distance vision until they discover that other children see better than they can. For example, many school children first notice that they cannot read the chalkboard as well as their classmates. For others who never report a problem, poor distance vision is first detected during vision screening or comprehensive eye and vision examination.

The primary sign of myopia is reduced unaided distance visual acuity, which can be corrected to standard or near-standard levels with the appropriate minus power optical correction. The uncorrected visual acuity level and the degree of uncorrected myopia are highly correlated.[104-106]

In nocturnal myopia, the results of retinoscopy in a dark room may be shifted in the minus direction, compared with the standard manifest refraction. Patients who have nocturnal myopia often complain of difficulty driving at night and/or blurred distance vision at night.

Patients with pseudomyopia frequently have fluctuations in distance visual acuity that correspond to fluctuations in accommodation. These fluctuations in accommodation may be observable as variations in visual acuity and retinoscopic reflex and, sometimes, changes in pupil diameter. The definitive sign of pseudomyopia is significantly more minus power on the manifest refraction than on the cycloplegic refraction. This additional minus power cannot be eliminated with the standard refraction procedures used to relax accommodation at distance.

Degenerative or pathological myopia is generally high myopia that is congenital or of early onset. Corrected visual acuity may be reduced as a result of pathological changes in the posterior segment. Abnormal or adverse ocular changes in degenerative myopia can include:[16,107-114]

- Vitreous liquefaction and posterior vitreous detachment
- Peripapillary atrophy appearing as temporal choroidal or scleral crescents or rings around the optic disc
- Lattice degeneration in the peripheral retina
- Tilting or malinsertion of the optic disc, usually associated with myopic conus
- Thinning of the retinal pigment epithelium with resulting atrophic appearance of the fundus
- Ectasia of the sclera posteriorly (posterior staphyloma)
- Breaks in Bruch's membrane and choriocapillaris, resulting in lines across the fundus called "lacquer cracks"
- Fuchs' spot in the macular area.

The observation of some of these signs in isolation does not necessarily indicate pathological myopia. For example, small choroidal crescents on the temporal side of the optic disc are often seen in simple myopia. Patients with degenerative myopia may complain of floaters or flashes of light associated with retinal changes.

Patients with myopia are more likely to have a retinal detachment than patients with hyperopia, and the risk for retinal detachment increases as myopia increases.[115] One study found that the risk of developing retinal detachment in a person with 10 D or more myopia is 1 in 148, compared with 1 in 48,913 for persons who have less than 5 D of hyperopia and 1 in 6,662 for persons who have less than 5 D of myopia.[115] Patients with myopia are also more likely than those with hyperopia to have most forms of glaucoma; vision loss can occur at lower intraocular pressures when the patient is myopic.[116-119] Because of these associations with retinal detachment and glaucoma, degenerative myopia is one of the leading causes of blindness in the United States, United Kingdom, and Canada.[120-123]

3. Early Detection and Prevention

Reduced unaided distance visual acuity is a possible indication of myopia, particularly when unaided near visual acuity is normal or better than unaided distance acuity. Myopia can be detected by visual acuity testing, retinoscopy, autorefraction, or photorefraction during vision screening or clinical examination. The Modified Clinical Technique, one of the most common vision screening test batteries, includes visual acuity, ophthalmoscopy, retinoscopy, and a cover test.[124] Some screening programs include autorefraction or photorefraction rather than retinoscopy. Patients or their parents should be cautioned that screenings do not substitute for a comprehensive eye and vision examination. Visual acuity testing, retinoscopy, autorefraction, or photorefraction alone cannot distinguish among the types of myopia.

There is no universally accepted method of preventing myopia. However, some clinicians identify nearpoint vision stress as a possible contributor to the development of simple myopia. When presented with signs of nearpoint vision stress, such as distance blur, poor accommodative facility, and refraction at about plano, some clinicians recommend regimens such as the following:[125]

- Plus power lenses in single-vision or bifocal form for reading and near work, as indicated by phoria, relative accommodation, or other findings

- Vision therapy or orthoptics to eliminate deficiencies in accommodation and vergence function

Further research into the risk factors relating to incipient myopia is needed to clarify and support these clinical interventions.

II.   CARE PROCESS

This Guideline describes the optometric care provided for a patient with myopia. The components of patient care described are not intended to be all inclusive because professional judgment and individual patient symptoms and findings may have significant impact on the nature, extent, and course of the optometric services provided. Some components of care may be delegated.

A.   Diagnosis of Myopia

The evaluation of a patient with myopia includes the elements of a comprehensive eye and vision examination* with particular emphasis on the following areas.

1.   Patient History

The major components of the patient history include a review of the nature of the presenting problem and chief complaint, visual, ocular, and general health history, developmental and family history, use of medications and medication allergies, and vocational and avocational vision requirements.

a.   Simple Myopia

The only symptom typical of simple myopia is blurred distance vision. It is important to discern whether the blurred distance vision is constant or transient. In simple myopia, the distance blur is constant. Near

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*   Refer to the Optometric Clinical Practice Guideline on Comprehensive Adult Eye and Vision Examination and the Optometric Clinical Practice Guideline on Pediatric Eye and Vision Examination.

vision may be "normal" if patients adjust near working distance to coincide with the linear reciprocal of the dioptric amount of the refractive error. Symptoms other than distance blur may represent some other coexisting condition. Clinicians should recognize that undiagnosed myopic children may not report blurred distance vision.

b.   Nocturnal Myopia

The primary symptom of nocturnal myopia is blurred distance vision in dim illumination. Patients may complain of difficulty seeing road signs when driving at night.

c.   Pseudomyopia

A distance blur that is transient, especially when it is greater after near work, may indicate accommodative infacility or pseudomyopia.

d.   Degenerative Myopia

In degenerative myopia, there is a considerable blur at distance because the degree of myopia is typically significant. The patient has to hold nearpoint objects quite close to the eyes, due to the magnitude of the uncorrected myopia. The patient may notice flashes of light or floaters associated with vitreoretinal changes. If pathological posterior segment changes have affected retinal function, the patient may have a history of vision loss and, perhaps, report the use of low vision services or devices. Patients with degenerative myopia may also express concern about the high power of their optical correction, and they often have some discomfort due to the weight or inconvenience of the correction.

e.   Induced Myopia

Patients with induced myopia also report blurred distance vision. The time course of the distance blur depends upon the agent or the condition that has induced the myopia. Whether other symptoms are present depends upon the cause of the induced myopia. The pupils are constricted when the cause of induced myopia is exposure to cholinergic agonist pharmaceutical agents.

2.   Ocular Examination

a.   Visual Acuity

Both unaided distance and near visual acuities should be measured. Because of the correlation of unaided distance visual acuity with the degree of myopia, visual acuity provides a means of checking the internal consistency of refractive findings, provided the reduced visual acuity is only a function of the myopia, and not another ocular condition (e.g., high astigmatism). When the patient regularly wears an optical correction, aided visual acuity should be measured.

b.   Refraction

Retinoscopy provides an objective measure of refractive error and yields a good approximation of the subjective refraction.[126] Use of an objective autorefractor may be substituted for retinoscopy,[127,128] although an autorefractor will not give the qualitative information (e.g., clarity of the ocular media, optical quality of the retinoscopic reflex, and fluctuations in pupil size) that retinoscopy does. Retinoscopy in a completely darkened room may be useful in the diagnosis of nocturnal myopia, although there is no proven procedure for the correction of nocturnal myopia.[11,129]

A careful subjective refraction should be conducted to determine the lowest minus lens power that achieves best visual acuity. A cycloplegic refraction is required for the definitive diagnosis of pseudomyopia. Keratometry can be useful in predicting the degree of any astigmatism by Javal's rule or a simplification of Javal's rule.[130-132]

c. Ocular Motility, Binocular Vision, and Accommodation

Because convergence excess, accommodative insufficiency, and accommodative infacility are frequently observed in patients with myopia,[65,125] testing should include assessment of accommodation, vergence, and binocularity. Measurement of heterophoria, dynamic retinoscopy, accommodative facility testing, versions, and other related measurements may be indicated. The specific tests selected should be age appropriate.

d. Ocular Health Assessment and Systemic Health Screening

Examination of the patient with myopia should include direct or indirect ophthalmoscopy or fundus biomicroscopy and measurement of intraocular pressure. This testing is indicated not only for preventive evaluation, but also because of the increased risk for glaucoma, retinal and choroidal atrophy, and retinal breaks and detachment in patients with myopia. Viewing of the peripheral retina is enhanced by pupillary dilation and is of particular importance in pathological myopia. Slit lamp biomicroscopy can be important in the differential diagnosis of induced or acquired myopia, including myopia from contact lens-induced corneal edema or from age-related lenticular nuclear sclerosis.[17]

**3.	Supplemental Testing**

Additional procedures may be indicated for identifying associated conditions and documenting and monitoring retinal changes in patients with degenerative myopia. These additional procedures may include:

- Fundus photography
- A- and B-scan ultrasonography
- Visual fields
- Tests such as fasting blood sugar (e.g., to identify causes of induced myopia).

**B.	Management of Myopia**

The range of services an optometrist may provide in the treatment of myopia varies, depending on state scope of practice laws and regulations and the individual optometrist's certification. The vast majority of patients with myopia can be treated by most primary care optometrists, but treatment of some patients with myopia may require referral for consultation or treatment by another optometrist or ophthalmologist for services outside the primary care optometrist's scope of practice (See Appendix Figure 1.)

**1.	Basis for Treatment**

The goals for management of the patient with myopia are clear, comfortable, efficient binocular vision and good ocular health. The primary symptom in patients with low and moderate myopia is lack of clear vision at distance, which can be restored by optical correction. Treatment directed to slowing the progression of myopia is referred to as "myopia control". Effective myopia control results in less severe myopia and less vitreous chamber elongation than would otherwise have occurred. Regimens to reduce

myopia lessen dependence on spectacles or contact lenses, but they do not lessen the risk for myopia sequelae.

2. Available Treatment Options

a. Optical Correction

Optical correction in the form of spectacles or contact lenses provides clear distance vision. Whether spectacles or contact lenses are preferable in a given case depends upon numerous factors, including patient age, motivation for wearing contact lenses, compliance with contact lens care procedures, corneal physiology, and financial considerations. It is the optometrist's responsibility to advise and counsel the patient regarding the optical correction options available and to guide the patient in the selection of the appropriate spectacles and/or contact lenses.

Spectacles and contact lenses each have particular advantages. Some advantages of spectacles for patients with myopia are:

- Spectacles may be more economical in many cases.
- Spectacles provide some eye safety, particularly when the lenses are of polycarbonate materials.
- Spectacles readily allow the incorporation of other optical treatments (e.g., prism, bifocals, or progressive addition lenses) which can be used for the management of esophoria or any accommodative disorders accompanying myopia.
- Spectacles require less accommodation than contact lenses for myopia, so that the likelihood of accommodative asthenopia or nearpoint blur in patients approaching presbyopia may be less.
- Spectacles provide better correction of some types of astigmatism.

Some advantages of contact lenses for patients with myopia are:

- Contact lenses provide better cosmesis.

- Contact lenses provide a larger retinal image size and slightly better visual acuity in severe myopia.

- Contact lenses result in less aniseikonia in anisometropia.[133-136]

- Contact lenses reduce the problems of weight, visual field restrictions, and the possibility of induced prismatic imbalance from the tilt of the spectacle frame experienced by some spectacle lens wearers.

- Contact lenses (e.g., rigid gas-permeable lenses) may reduce the rate of myopia progression due entirely or in part to corneal flattening.[137]

b.   Medical (Pharmaceutical)

Cycloplegic agents* are sometimes used to reduce accommodative response as part of the treatment of pseudomyopia.[138] Some studies have reported that daily topical administration of atropine[139-142] and cyclopentolate[142] reduces myopia progression rates in children with youth-onset myopia. However, this benefit does not seem to outweigh the discomfort and risks associated with chronic cycloplegia. The associated pupillary dilation results in light sensitivity. Because of the inactivation of the ciliary muscle, high plus lens additions (i.e., 2.50 D) are required for near vision. In addition to potential allergic reactions, idiosyncratic reactions, and systemic toxicity,[143] chronic application of atropine can have adverse effects on the retina.[144]

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*   Every effort has been made to ensure drug dosage recommendations are appropriate at the time of publication of the Guideline. However, as treatment recommendations change due to continuing

research and clinical experience, clinicians should verify drug dosage schedules with product information sheets.

c.   Vision Therapy

Unaided visual acuity can be improved in patients with myopia using vision therapy, but myopia does not appear to be reduced.[145-152] Procedures have been proposed for reducing myopic progression rates,[153,154] but no studies have tested their efficacy.

Vision therapy to reduce accommodative response is often provided for pseudomyopia.[138,155,156] Auditory biofeedback has also been used successfully in the treatment of pseudomyopia.[157,158]

d.   Orthokeratology

Orthokeratology is the programmed fitting of a series of contact lenses, over a period of weeks or months, to flatten the cornea and reduce myopia. Studies of orthokeratology with standard rigid contact lenses[159-170] show that individuals' responses vary considerably to orthokeratology, with myopia reduction up to 3.00 D obtained in some patients. The average reduction reported in studies was 0.75-1.00 D; most of this reduction occurs within the first 4-6 months of the orthokeratology program. Corneas with greater peripheral flattening are thought more likely to have successful central flattening, thus leading to reduced myopia via orthokeratology. With adequate followup care, orthokeratology is a safe and effective procedure. However, studies suggest that refractive error shifts toward the original baseline in patients who stop wearing contact lenses. The extent of shift varies from one patient to another, although myopia usually does not fully return to baseline level. Wearing retainer lenses several hours each day is generally required to maintain the improved refractive state.

Orthokeratology is thought to steepen the peripheral cornea as it flattens the central cornea. Some contact lenses that are specially designed to maximize these changes differ from standard, rigid lenses in that the secondary curve is steeper rather than flatter than the base curve. The mean myopia reduction with such lenses has been reported to be about 2 D.[171,172] Orthokeratology with such lenses results in a uniform, rather than irregular, corneal surface. Orthokeratology is generally performed only on adults, although the apparent control of myopia with rigid gas-permeable contact lenses in children is probably due to orthokeratology-like effects.

e. Refractive Surgery

There are several refractive surgery methods in use; others are in various stages of research and development.[173-175] One procedure is radial keratotomy (RK), in which a spoke-like radial pattern of incisions in the paracentral cornea weaken a portion of the cornea. The weakened part steepens while the central cornea flattens. The amount of resultant refractive change depends on the size of the optical zone and the number and depth of the incisions. RK has limited predictability, especially in more severe cases of myopia. Although everyone who undergoes RK experiences a reduction in myopia,[176] the patients most likely to be pleased with the outcome of the procedure are those who wish to decrease their reliance on spectacles or contact lenses.

The reported visual complications of RK include diurnal variation of refraction and visual acuity, glare, monocular diplopia, a presumably permanent reduction in best corrected visual acuity, increased astigmatism, irregular astigmatism, induced anisometropia, and a gradual shift toward hyperopia that continues for months or years after the surgical procedure.[176-185] This shift toward hyperopia can lead to early onset of presbyopic symptoms. RK incisions may also decrease the structural integrity of the globe.[186]

Excimer laser photorefractive keratectomy (PRK) is a procedure in which corneal power is decreased by laser ablation of the central cornea. The compiled results of several studies of this procedure show that 48-92 percent of patients have achieved 6/6 (20/20) unaided visual acuity after PRK.[177,187-195] One-half, or one line, of best corrected visual acuity was lost by 0.4-29 percent of patients.[177,187-189,191,193-196] Corneal haze is common after PRK and takes a few months to resolve. Patients sometimes report that without correction, they see better than before refractive surgery, but that with correction, they do not see as well as before the surgery.[175] PRK refractive results appear to be more predictable than those of RK.[197,198] Vision-threatening complications, particularly corneal complications, occur after 1-2 percent of PRK procedures for moderate myopia.[199] Some studies have reported reduced contrast sensitivity following PRK.[199] In one study, the mean best corrected high contrast visual acuity was reduced by one line, and the mean best corrected low contrast visual acuity was reduced by half a line one year after PRK.[200] Glare and perceived distortion are commonly reported.[201] Visual complaints after refractive surgery may be related to aberrations in the eye's optics induced by the surgical procedures.[202]

RK and PRK are the most common refractive surgery procedures for cases of low or moderate myopia. Additional refractive surgery procedures for myopia include cryolathe keratomileusis, automated lamellar keratomileusis (ALK), and laser in situ keratomileusis (LASIK).[175,203] In cryolathe keratomileusis, a section of corneal stroma is removed, frozen, and shaped on a lathe to minus power. It is then replaced in the cornea to reduce corneal power. Cryolathe keratomileusis is used for more severe myopia.

In ALK, a layer of corneal epithelium and superficial stroma of predetermined thickness is removed with a microkeratome except for a small section providing an attachment to the cornea. The microkeratome is then used to remove a specific amount of corneal stroma to flatten the cornea after which, the flap of superficial corneal tissue is replaced. LASIK is similar to ALK, except that corneal stromal tissue is removed by a laser rather than by microkeratome. The complications of LASIK and ALK have not been studied as extensively as those for RK and PRK. The LASIK procedure is gaining popularity among

surgeons. Clinicians should consult the most recent literature for information on refractive surgery and comanagement of refractive surgery patients in this rapidly changing field.

The best candidates for refractive surgery are patients who are highly motivated to have better unaided visual acuity and decreased reliance on spectacles or contact lenses. Patients who are concerned about seeing as well as possible, with correction if necessary, are not good candidates due to the potential decrease in best corrected visual acuity. Patients undergoing myopia progression should not have refractive surgery. Refractive surgery should not be performed on myopic patients prior to physical maturity or others whose myopia has not stabilized. Although refractive surgery is usually successful in reducing myopia, the patients for whom it is most likely to be successful--those with less severe myopia-- may regret that they are no longer myopic when they become presbyopic.

3.   Management Strategy for Myopia Correction

a.   Simple Myopia

- **Pediatric Cases**. It is generally not necessary to correct myopia of less than about 3 D in infants and toddlers. Myopia of as much as 3 D in an infant will sometimes disappear by 2 years of age.[18,19] Myopia may also decrease in a child born prematurely; 50 percent reach emmetropia by age 7. Moreover, because infants interact for the most part with things that are close to them, they do not need clear distance vision. Myopia of more than 1.00-2.00 D in preschool children can be corrected with minus lenses, when the children's interactions involve persons and objects at intermediate distances. If the myopia is left uncorrected, the preschool myopic child should be examined at 6-month intervals. Optical correction should be prescribed if the myopia reaches a higher degree, thus making distance viewing more difficult, or if the child appears to have adverse behavioral effects caused by not being able to see clearly at far or intermediate distances.

Demands on both distance and near vision increase as children enter and progress through school. Vision screening programs often use distance visual acuity of 20/40, or 1.00 D of myopia, as the criterion for referral[116] during children's first few grades in school. It may be prudent for clinicians to use one or both of these criteria as a guide in correcting myopia in children.

- **Adolescent and Adult Cases**. Most clinicians will proceed to correct any significant degree of myopia to improve distance visual acuity in the adolescent or adult patient. Persons who are more precise and discriminating than others are more likely to have visual complaints pertaining to very low refractive errors;[204] thus they are likely to benefit from the optical correction of a very small degree of myopia.

  Patients also differ in their occupational, educational, and recreational needs for distance vision. In general, any degree of myopia should be corrected any time the patient would be adversely affected by the lack of clear distance vision. In cases of high exophoria or intermittent exotropia, a prescription for full-time wear of the full refractive correction for myopia is warranted. In cases of esophoria at near or accommodative insufficiency, a plus lens addition for near may be appropriate.

  An option for the patient with very low ametropia is to try to improve the visual environment before prescribing lenses.[204] For example, an option to present to the parents of a grade school child with 0.50 D of myopia who complains of difficulty seeing the chalkboard from the back of the classroom is to ask the teacher to move the child toward the front of the room.[205]

  Because the 95 percent limits of agreement for repeatability of subjective refraction is about 0.50 D,[206] a change in refraction of about 0.50 D from the patient's existing spectacle correction is an indication for a prescription change. Patients who are more sensitive to slight amounts of blur may report much better vision with prescription changes of as little as 0.25 D. A trial frame

demonstration of the difference between the new refraction and the existing correction can be helpful in deciding whether the patient is obviously able to appreciate improved vision with the new correction when the difference is small.

- **Myopic Astigmatism**. In cases of compound myopic astigmatism, some cylinder correction should generally be incorporated in the prescription when the amount of astigmatism is 0.50 D or greater. If the patient has successfully worn a correction with 0.25 D cylinder, cylinder correction of as little as 0.25 D can be incorporated in the new prescription. Any of these guidelines for correction of simple myopia should be applied judiciously; the clinician should apply professional judgment, considering such factors as the patient's occupational, scholastic, and recreational needs.

- **Accommodation and Vergence**. It is important to consider the patient's accommodation and vergence functions. Full-time wear of the full minus power correction for myopia may be recommended for young patients with high exophoria, a moderate accommodative convergence/accommodation (AC/A) ratio, and normal accommodative function. A nearpoint plus lens addition (i.e., reduced minus power for near viewing, compared with the distance correction) is often indicated for nonpresbyopic patients with accommodative insufficiency or convergence excess.[207-210] The plus lens addition can be provided by either a bifocal lens or a progressive addition lens. Patients who have a relatively low degree of myopia and little or no astigmatism or anisometropia can also be advised to remove their glasses for reading.

b.   Nocturnal Myopia

When nocturnal myopia is diagnosed, the prescription for minus lenses for use only at night or in darkened conditions can be based on an arbitrary increase in minus power or possibly the results of the dark room retinoscopy procedure. For patients who require spectacle correction of myopia under normal

illumination, the prescription for a second pair of glasses for nighttime seeing can incorporate the additional minus power.

c.   Pseudomyopia

The goal of treatment for pseudomyopia is to relax the patient's accommodation. The full minus lens power from the manifest refraction should not be prescribed for long-term use. Although this minus power may improve the patient's distance visual acuity, it will not aid in reducing accommodative response. Treatment to reduce accommodative dysfunction may include one or a combination of the following:

- Vision therapy
- Instillation of a cycloplegic agent to eliminate accommodative spasm
- Nearpoint plus lens addition
- Instruction in visual hygiene.

Plus lenses alone may not eliminate pseudomyopia, but often they can prevent another occurrence of pseudomyopia by keeping accommodative response at a lower level. Pseudomyopia occasionally occurs secondary to high exophoria as a means of maintaining fusion through accommodative convergence. In such cases, vision therapy to improve positive fusional convergence can be added to the basic treatment for pseudomyopia.

d.   Degenerative Myopia

Contact lenses offer the advantages of expanded visual field and improved cosmesis in the correction of high myopia. A disadvantage of contact lenses for high myopia, especially in presbyopic patients, is that greater accommodation is required with contact lenses than with spectacle lenses, resulting in the

possibility of nearpoint blur and eyestrain. When spectacles are prescribed, the clinician should attempt to minimize weight and optimize the appearance of the spectacles by using small eye sizes, round lens shapes, high-index lenses, thick eyewire frames, dark frames, and antireflection coatings. The prescription for spectacle lenses for severe myopia should include a carefully derived interpupillary distance measurement due to the possibility of significant induced prism when high-power lenses are not properly centered. For cases of severe myopia, adjustment for vertex distance should be determined and incorporated in lens prescriptions.

The management of degenerative myopia should include appropriate treatment for retinal complications. Patients should be educated about the symptoms of retinal detachment and the need to seek immediate care if they experience such symptoms. Low vision services can be provided when best corrected visual acuity levels are significantly reduced.

e.   Induced Myopia

The treatment for induced myopia depends upon the causative agent. This treatment may involve preventing future exposure to the agent (e.g., in cholinergic pharmaceutical agent-induced myopia), referral to an appropriate practitioner for additional testing and treatment (e.g., refractive shifts thought to be due to changes in blood glucose level or nuclear sclerosis of the lens that has advanced to a stage indicating cataract extraction), or other treatment appropriate for the particular causative agent. Table 4 lists pharmaceutical agents that can induce myopia.

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Insert Table 4 here

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4.   Management Strategy for Control of Simple Myopia

Myopia control is the attempt to slow the rate of progression of myopia. The most commonly used methods of myopia control are plus lenses at near and rigid contact lenses.

a.   **Plus at Near**

The effectiveness of the prescription of plus lens power at near in a bifocal lens form has been the subject of considerable research. Among several studies of the effectiveness of bifocal lenses for myopia control in children,[211] some found no statistically significant reduction in myopia progression rates with bifocals,[212-214] while others found that bifocals controlled myopia.[215-218] Many of these studies have been retrospective, some conducted with relatively small numbers of subjects. Whereas most of the studies did not have masked examiners, the results may have been affected by examiner bias. Some studies have reported that myopia control with bifocals is related to particular clinical test findings: One study found greater control of childhood myopia progression when intraocular pressure was greater than or equal to 17 mm Hg.[219] Other investigators noted a reduction of mean myopia progression rates of about 0.2 D per year with bifocals in children who have nearpoint esophoria.[217,220-223]

It is advisable to fit bifocals slightly higher in nonpresbyopic than in presbyopic patients, and to make sure that the spectacle frame is maintained in good adjustment. There is no general agreement on the most effective power of the near addition. Some studies suggest that near add powers of about 1.00 D appear to be as effective or more effective than higher power adds.[211,217] Progressive addition lenses can also be used in nonpresbyopic patients.[224,225] Additional studies may help to confirm whether, and when, near plus additions can be effective in slowing myopia progression rates in children. Near plus lens additions are commonly used in patients with near esophoria to relieve asthenopia and improve near vision efficiency. Thus, bifocals or progressive addition lenses can be useful in myopic patients with nearpoint esophoria, regardless of whether the near plus add slows the progression of myopia. Studies of the effect of bifocals on rates of childhood myopia progression are summarized in Table 5.

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Insert Table 5 Here

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b.   Rigid Contact Lenses

Rigid gas-permeable contact lenses have been reported effective in slowing the rate of myopia

progression in children.[137] In one study, the mean 3-year increase in spherical equivalent myopia among

56 rigid gas-permeable contact lens wearers was 0.48 D (standard deviation, SD, 0.70),[137] and the mean

increase among 20 spectacle lens wearers was 1.53 D (SD, 0.81). The contact lens group had an

average corneal flattening of 0.37 D, which did not account for the full 1.05 D difference in myopia

progression between the wearers of contact and spectacle lenses. One possible explanation is that there

may have been more flattening at the corneal apex than at the region of the cornea measured by the

keratometer.[137] However, since the contact lenses were fitted in approximate alignment with the cornea,

it is difficult to explain their ability to induce the required amount of corneal flattening. An alternative

explanation is that the contact lenses have an effect on axial elongation of the eye.[137] The contact lens

wearers' eyes continued to elongate: Axial elongation averaged 0.48 mm (SD, 0.48) throughout the 3

years of the study.[137] Unfortunately, axial elongation measurements were not obtained on the spectacle

lens wearers, but it is possible that their axial elongation was even greater.

Twenty-three members of the contact-lens wearing group discontinued contact lens wear after

completion of the study.[226] These subjects' average increase in myopia was 0.76 D during 44 months of

contact lens wear. During the 2.5 months in which they did not wear contact lenses, their myopia

increased 0.27 D, and keratometery findings showed a mean corneal steepening of 0.25 D.[226] These

patients' mean increase in axial length was 0.65 mm after 44 months of contact lens wear, and the mean

change after an additional 2.5 months, during which contact lenses were not worn, was negligible (0.03

mm). It appears that the myopia increase during that 2.5 month period was due to corneal steepening.

Myopia control with rigid gas-permeable contact lenses appears to be due to corneal flattening and perhaps some slowing of axial elongation of the eye. To the extent that the vitreous chamber elongation responsible for the progression of childhood myopia continues during the years when contact lenses are worn, the control of myopia with rigid contact lenses would not reduce the chance of developing posterior segment sequelae of myopia. In addition, there appears to be a rebound effect (i.e., resteepening of the cornea) when lens wear is discontinued.

c.   Vision Therapy and Visual Hygiene

Some clinicians suggest that some myopia control can result from the use of vision therapy to improve accommodation and vergence functions and from recommendations for improved visual hygiene (i.e., reading conditions and lifestyle).[227-231] There is no evidence that these procedures are effective myopia controls; however, the visual hygiene recommendations appear useful regarding efficiency in reading and visual work, and they make good common sense, regardless of whether they control myopia effectively. Visual hygiene recommendations include the following:[227-231]

- When reading or doing intensive near work, take a break about every 30 minutes. During the break, stand up and look out a window.
- When reading, maintain proper distance from the book. The book should be at least as far from your eyes as your elbow when you make a fist and hold it against your nose.
- Be sure illumination is sufficient for reading. Avoid glare on the page by using a diffuse light source and allowing it to shine on the page from behind you (over your shoulder), rather than shining or reflecting toward you.
- Read or do other visual work using a relaxed upright posture.
- Place a limit on the time spent watching television and watching video games. Sit 5-6 feet away from the television.

5.   Patient Education

a.   Simple Myopia

Clinicians should inform parents of children with simple myopia that has its onset in childhood that the condition almost always increases in severity until the progression slows or stops in the mid to late teens. Clinicians should also tell parents about the options available for myopia correction, possible myopia control, or myopia reduction in their children. Young adults with myopia can be told that increases in myopia during young adulthood are not uncommon. In some patients the increase in simple myopia may continue into the third decade of life.

When spectacles are prescribed, the clinician should advise the patient about the use of polycarbonate lenses for eye protection. Instructions should be given concerning the frequency of wearing spectacles or contact lenses. Patients with low degrees of myopia and insignificant degrees of astigmatism and anisometropia can be told to take their glasses off to read, especially if they have esophoria at near or have a high lag in accommodation. The optometrist should educate patients and parents about the importance of regular followup care.

b.   Nocturnal Myopia

Patients with nocturnal myopia should be educated about the nature of the dark focus of accommodation and nocturnal myopia. Optometrists should instruct patients with nocturnal myopia to wear the correction for nighttime seeing under dark conditions, such as when driving at night.

c.   Pseudomyopia

Patients with pseudomyopia should be educated concerning the nature of accommodation and pseudomyopia. They should be told that the goal of treatment for pseudomyopia is to relax accommodation. Clinicians should explain that periods of blurred distance vision occur when accommodation is not relaxed, and that blurred distance vision may occur periodically until accommodative response is reduced.

d.   Degenerative Myopia

Patients with degenerative myopia should be advised to have annual or more frequent eye and vision examinations, depending upon the severity of ocular changes. Patients need to understand the importance of regular retinal examination, visual fields testing, and measurement of intraocular pressure. Clinicians should educate them about the causes and symptoms of retinal break or detachment and glaucoma. Patients should also be advised to seek immediate care if they experience the onset of symptoms. Patients with degenerative myopia should be instructed to avoid the causes of blunt trauma and to wear eye protection when they are at risk for blunt ocular trauma (e.g., playing tennis, racquetball).

e.   Induced Myopia

Patients with induced myopia should be educated about the agent or condition inducing the myopia and the nature of the changes occurring in the eye. Clinicians should inform patients whether the induced myopia will be temporary or long standing and, if appropriate, how to avoid the induced myopia in the future.

6.   Prognosis and Followup

The prognosis for correction of simple myopia is very good. Patients can achieve better distance vision with correction. Depending upon the degree of myopia, astigmatism, anisometropia, and the patient's accommodation and vergence functions, the patient may or may not see better at near with correction.

Appendix Figure 2 summarizes recommendations for followup care. Children with simple myopia should be examined annually. Followup at 6-month intervals may be appropriate for children who have unusually high myopia progression rates. Adults with simple myopia should be examined at least every 2 years. Followup examination should be more frequent when warranted by any other co-existing conditions. Contact lens wearers generally require more frequent followup for evaluation of lens fit and corneal physiology. When no prescription is given for simple myopia of a low degree that is expected to increase (e.g., in a young child with -0.50 to -0.75 D of myopia), followup should be scheduled at about 6-month intervals.

The patient with nocturnal myopia should be evaluated 3-4 weeks after receiving the correction for nighttime seeing, to determine whether the correction has eliminated the symptoms of poor vision under darkened conditions and/or difficulty driving at night. After the symptoms have abated, the patient should subsequently be examined annually. The prognosis for correction of nocturnal myopia is good.

Treatments for pseudomyopia are usually successful, but the course of treatment may be slow and it may require several weeks. Followup examinations should be conducted at frequent intervals (e.g., every 1-4 weeks) until the accommodative excess and symptoms have been eliminated. Once accommodation has been relaxed, examinations should be conducted on an annual basis.

The prognosis for patients with degenerative myopia varies with the retinal and ocular changes that occur. Examinations should be conducted on an annual or more frequent basis, depending upon the nature and severity of retinal and ocular changes. Regular retinal examination, visual fields testing, and measurement of intraocular pressure are important aspects of followup care.

In cases of induced myopia, both prognosis and recommended frequency of followup examination

depend upon the inducing agent or condition.[17]

CONCLUSION

Myopia is a common refractive condition that can affect clarity of vision, limit occupational choices, and contribute to increased risk for vision-threatening conditions. The major symptom of myopia (blurred distance vision) and the major sign (reduced unaided distance visual acuity) can generally be improved with appropriate minus power lenses.

Simple myopia is much more common than the other types of myopia. The usual treatment for simple myopia is optical correction (i.e., the prescription of minus power spectacle lenses or contact lenses to restore distance visual acuity). Other treatment options include myopia control to attempt to reduce the rate of myopia progression in patients whose myopia is increasing or myopia reduction in patients whose myopia has stabilized. Myopia control with rigid contact lenses does not appear to reduce vitreous chamber elongation, nor does myopia reduction with corneal modification procedures alter existing axial elongation that has already occurred. Thus neither decreases the risk for the posterior segment sequelae of myopia.

The treatment for nocturnal myopia is to prescribe minus power correction for nighttime seeing only, to compensate for the dark focus of accommodation. The management for pseudomyopia involves eliminating the accommodative excess responsible for the pseudomyopia. Degenerative myopia is more severe than other forms of myopia and is associated with retinal changes, potentially causing loss of visual function. The management of degenerative myopia includes correction with minus lenses to improve distance vision and monitoring retinal and ocular changes. Because myopia can be induced by various agents and conditions, the treatment of induced myopia should be tailored to the specific inducing agent or condition.

The examination of patients who have any of the forms of myopia should include a comprehensive patient history, measurement of refraction, investigation of accommodation and vergence function, and

evaluation of ocular health. The patient should be advised about available treatment options and

counseled regarding the need for followup care.

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Figure 1
Optometric Management of the Patient with Myopia:
A Brief Flowchart

Patient history and examination

Supplemental testing

Assessment and diagnosis

Patient counseling and education

Treatment and management

Simple myopia

Nocturnal myopia

Pseudomyopia

Degenerative myopia

Induced myopia

Myopia correction

Infant and toddlers: No correction of myopia, <3 d

Preschool/ Early school-age children: Correct myopia >1-2D

Adolescents/ Adults: Correct any significant degree of myopia that improves distance visual acuity

Myopia control

Plus lens addition at near

Rigid contact lenses

Visual hygiene recommen-dations

Myopia reduction

Corneal modifi-cation: Orthokera-tology; refractive surgery

Myopia correction for nighttime seeing only

Reduction of accom-modative response:

Vision therapy; plus lens addition at near; cycloplegic agents; visual hygiene recommen-dations

Myopia correction and manage-ment of retinal changes

Identi-fication of inducing agent or condition and provision of treatment accordingly

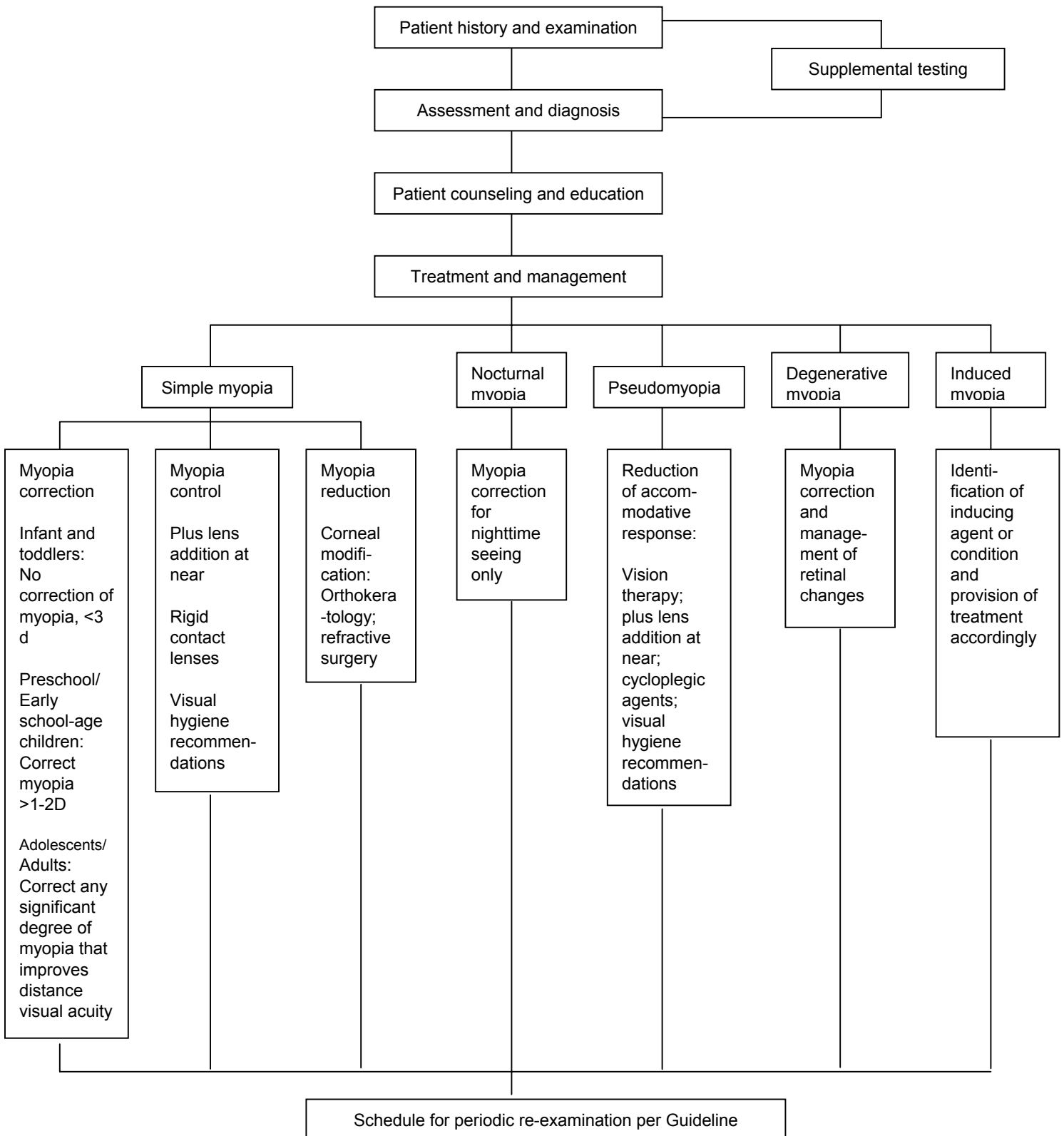Schedule for periodic re-examination per Guideline

Figure 2
Frequency and Composition of Evaluation and Management Visits for Myopia

Type of Patient	Number of Evaluation Visits	Treatment Options	Frequency of Followup Visits	Composition of Followup Evaluations				Management Plan
				VA	REF	A/V	OH	
Simple myopia	1	Myopia correction: optical correction, vision therapy	Children: annually Adults: every 2 yr or p.r.n.	Each visit	Each visit	Each visit	Each visit	Prescribe refractive correction; provide or refer patient for vision therapy; patient education.
		Possible myopia control: optical correction, vision therapy	Every 6 mo	Each visit	Each visit	Each visit	Contact lens: anterior segment each visit, posterior segment annually, Bifocals: annually	Prescribe refractive correction; provide or refer patient for vision therapy; recommend vision hygiene improvement; patient education.
		Myopia reduction: orthokeratology, refractive surgery	Variable, depending on method of myopia reduction	Each visit	Each visit	Annually	Anterior segment: each visit, Posterior segment: annually	Provide or refer patient for orthokeratology; refer patient for refractive surgery; patient education.
Nocturnal myopia	1-2	Optical correction	3-4 wk after dispensing of prescription, then annually	Each visit	Annually or p.r.n.	Annually	Annually	Prescribe refractive correction for nighttime seeing; patient education.
Pseudo-myopia	1-2	Optical correction, pharmaceuticals, vision therapy	Every 1-4 wk until accommodative excess is eliminated, then annually	Each visit	Each visit	Annually or p.r.n.	Annually	Prescribe refractive correction; reduce accommodative response with vision therapy; prescribe cycloplegic agents to eliminate accommodative spasm; prevent pseudomyopia with plus lenses; patient education.
Degenerative myopia	1-2	Optical correction	Annually or more frequently, depending on retinal and ocular changes	Each visit	Annually or p.r.n.	Annually or p.r.n.	Each visit	Prescribe refractive correction; provide or refer for appropriate treatment for retinal complications; patient education.
Induced myopia	1-2	Variable, depending on inducing agent or condition	Variable, depending on inducing agent or condition	Each visit	Each visit	Variable, depending on inducing agent or condition	Variable, depending on inducing agent or condition	Identify inducing agent, prevent further exposure to causative agent; refer to appropriate practitioner for additional testing and treatment; patient education.

p.r.n. = as necessary
VA = visual acuity testing
REF = refraction

A/V = accommodative vergence testing
OH = ocular health assessment

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Figure 3
ICD-9-CM Classification of Myopia

Degenerative disorders of globe	**360.2**
Progressive high (degenerative) myopia Malignant myopia	**360.21**
Myopia Near-sightedness	**367.1**
Disorders of accommodation	**367.5**
Spasm of accommodation	**367.53**
Other disorders of refraction and accommodation	**367.8**
Transient refractive change	**367.81**
Other Drug-induced disorders of refraction and accommodation Toxic disorders of refraction and accommodation	**367.89**
Unspecified disorder of refraction and accommodation	**367.9**

Abbreviations of Commonly Used Terms

AC/A ....Accommodative convergence/accommodation

ALK..................Automated lamellar keratomileusis

D.......................Diopter

LASIK ....Laser in situ keratomileusis

PRK.................Photorefractive keratectomy

RK ....Radial keratotomy

Glossary

Accommodative insufficiency Less accommodative amplitude than expected for the patient's age.

Anisometropia Condition of unequal refractive state for the two eyes, in which one eye requires a significantly different lens correction than the other.

Astigmatism Refractive anomaly due to unequal refraction of light in different meridians of the eye, generally caused by a toroidal anterior surface of the cornea.

Convergence excess (CE) Vergence condition characterized by orthophoria or near-normal phoria at distance and esophoria at near.

Emmetropia Refractive condition in which an infinitely distant object is imaged sharply on the retina without inducing an accommodative response.

Esophoria Vergence position in which the two eyes' lines of sight cross closer to the patient than the object of regard when binocular fusion is disrupted, the magnitude of the deviation being the same at both far and near fixation distances.

Retinal detachment Separation of the sensory retina from underlying structures, resulting in potential loss of vision.

Vision therapy Treatment process for the improvement of visual perception and coordination of the two eyes for efficient and comfortable binocular vision. Synonyms: orthoptics, vision training.

Visual acuity The clearness of vision that depends upon the sharpness of focus of the retinal image and the integrity of the retina and visual pathway.

Source: Cline D, Hofstetter HW, Griffin JR. Dictionary of visual science, 4th ed. Radnor, PA: Chilton, 1989.

Table 1

Classification Systems for Myopia

Type of Classification	Classes of Myopia
Clinical Entity	Simple myopia
	Nocturnal myopia
	Pseudomyopia
	Degenerative myopia
	Induced myopia
Degree	Low myopia (<3.00 D)
	Medium myopia (3.00 D-6.00 D)
	High myopia (>6.00 D)
Age of Onset	Congenital myopia (present at birth and persisting through infancy)
	Youth-onset myopia (<20 years of age)
	Early adult-onset myopia (2-40 years of age)
	Late adult-onset myopia (>40 years of age)

Table 2

Possible Risk Factors for Myopia Development

Family history of myopia

Presence of myopia on noncycloplegic retinoscopy in infancy, decreasing to emmetropia before entry into school

Refractive error of emmetropia to 0.50 D of hyperopia

Against-the-rule astigmatism

Decreased accommodative function or nearpoint esophoria

Substantial amount of near work on a regular basis

Steep corneal curvature or high axial length to corneal radius ratio

Conditions temporarily obscuring the retina from clear imagery during infancy

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Table 3

Possible Etiologies of Myopia by Classification

Type of Myopia	Etiologies
Simple Myopia	Inheritance Significant amounts of near work Unknown
Nocturnal Myopia	Significant levels of dark focus of accommodation
Pseudomyopia	Accommodative disorder High exophoria Cholinergic agonist agents
Degenerative Myopia	Inheritance Retinopathy of prematurity Interruption of light passing through ocular media Unknown
Induced Myopia	Age-related nuclear cataracts Exposure to sulfonamides and other pharmaceutical agents Significant variability in blood sugar level

Table 4

Pharmaceutical Agents That Can Induce Myopia*

Cholinergic agonists

Acetylcholine

Carbachol

Demecarium

Diisopropyl fluorophosphate

Neostigmine

Physostigmine

Pilocarpine

Antibiotics

Isoniazid

Sulfonamides

Tetracycline

Antianginal agents

Isosorbide dinitrate

hormone

Antihypertensives

Adrenergic drugs

Thiazide diuretics

Antiallergy medications

Antihistamines

Anticonvulsants

Methsuximide

Nervous system agents

Morphine

Opium

Phenothiazines

Heavy metals

Arsenicals

Hormonal agents

Adrenocorticotrophic

Corticosteroids

Oral contraceptives

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*   Modified from Amos JF, ed. Diagnosis and management in vision care. Boston: Butterworths,
        1987:313-67, 431-59.

Table 5
Effect of Bifocals on Progression of Myopia in Childhood*
Research Results*

Study, Location	Subject-no., age (yr)	Type of Bifocal	Progression of Myopia		Summary/Interpretation
			Single Vision Lenses, Mean D/yr	Bifocal Lenses, Mean D/yr	
Miles[215] St. Louis, MO	SV: 103, age 6-14 SV then BF: 48, age 8-16	28 mm wide flat-top segments decentered for slight base-in effect	0.75	0.40	Rates were lower after switch to BF: age is a potential confounding factor, but visual inspection of graphs suggests lower rates with BF over common age spans.
Roberts and Banford[216] New York	SV: 396 BF: 85 Examined at least twice before age 17	Most additions +0.75 to +1.50D in power	All: -0.41 Orthophoria and Exophoria: : -0.41 Esophoria: -0.48	All: -0.31	Rates were siginificantly lower in BF wearers than in SV group, the difference being greatest for patients with nearpoint esophoria and high AC/A ratios.
Oakley and Young[217] Oregon	SV: 298 BF: 269	Flat-top segments with top at pupil center, +1.50 to +2.00 D addition	Caucasians: -0.53 Native Americans: -0.38	Caucasians: -0.02 Native Americans: -010	Larger reduction in rate with BF than in any other study, which Oakley and Young attributed to high placement of addition or possible indavert-ent investigator bias.
Neetens and Evens[218] Holland	SV: 733 BF: 543 Patients who had myopia of <0.50 D at age 8 or 9	Total nearpoint power equal to zero for myopia up to 3D; myopia ≥3D: +2.50 addition	-0.45	-0.30	Mean of myopia at age 18 was less for BF wearers (-3.55 D) than for SV wearers (-5.07 D).
Schwarts[213] Washington, DC	25 monozygotic twin pairs, 1 of each in BF and in SV groups; ages 7-13 at start of study	+1.25 D addition	-0.28	-.24	Differences in rates for SV and BF groups not statistically significant; overall rate lower than rates in other studies.
Grossenor et al.[212] Houston, TX	SV: 39 BF +1.00 D: 41 BF +2.00 D: 44, age 6-15 at start of study	Executive bifocals; top of reading segment 2mm below pupil center	-0.34	+1.00 additions: -0.35 +2.00 additions: -0.34	No significant difference in mean rates between SV group, +1.00 D addition BF group, and +2.00 D addition BF group.
Pärssinen et al.[214] Finland	240 children mean beginning age 10.9 3 study groups: (1) full-time wear of SV lenses, (2) distance use only, SV lenses, (3) BF lenses	28 mm wide flat-tops; to of reading segment 2-3 mm below pupil center; +1.75 D addition	-0.57	-0.53	Mean refractive change for BF group not significantly different from that for either SV group.

AC/A = accommodative convergence/accommodation; BF = bifocal; D = diopter; SV = single vision
* Modified from Goss DA. Effect of spectacle correction on the progression of myopia in children: a literature review. J Am Optom Assoc 1994; 65:117-28.

Study, Location	Subject-no., age (yr)	Type of Bifocal	Progression of Myopia		Summary/Interpretation
			Single Vision Lenses, Mean D/yr	Bifocal Lenses, Mean D/yr	
Jensen[219] Denmark	SV: 49 BF: 51 Children, 2nd-5th grade at start of study	35 mm wide segment; top of segment at lower pupil margin; +2.00 D addition	All: -0.57 IOP≤16: 0.43 IOP≥17: -0.66	All: -0.48 IOP≤16: 0.47 IOP≥17: -0.49	Refractive change somewhat less with BF than with SV, but not statistically significant; for children with IOP ≥17 mm Hg, change less with BF than with SV.
Goss[220] Illinois, Iowa and Oklahoma private practices	SV: 52 BF: 60 Age 6-15	Various addition powers, mostly +0.75 D and +1.00 D	All: -0.44 >6▲ exophoria: -0.47 0-6▲ exophoria: -0.43 Esphoria: -0.54	All: -0.37 >6▲ exophoria: -0.48 0-6▲ exophoria: -0.45 Esphoria: -0.32	Rate of progression lower with BF in patients with nearpoint esophoria; no difference for patients with orthophoria and exophoria
Goss and Grosvenor[221] Houston, TX	SV: 32 BF: 65 Age 6-15; reanalysis of Grosvenor et al. data[212]	Executive bifocals; +1.00 D and +2.00 D additions	>6▲ exophoria: -0.50 0-6▲ exophoria: -0.43 Esphoria: -0.51	6▲ exophoria: -0.43 0-6▲ exophoria: -0.42 Esphoria: -0.31	Difference between rates for esophoric patients wearing BF and SV similar to findings of Roberts & Banford and of Goss; not statistically significant due to small sample size.
Fulk and Cyert[223] Oklahoma	SV: 14 BF: 14 Boys age 6.00-13.99; girls, 6.00-12.99, all with esophoria at near; study followup had esophoria at near; study followup 18 mo	28 mm wide flat-tops, top of segment 1 mm above lower limbus; +1.25 D addition	-0.57	-0.39	Bifocals did not show reduction in rate until third 6 months; overall rates not significantly different in BF and SV groups due to small sample size, but magnitude of difference was similar to that found by Roberts & Banford, Goss, and Goss & Grosvenor.

AC/A = accommodative convergence/accommodation; BF = bifocal; D = diopter; SV = single vision
* Modified from Goss DA. Effect of spectacle correction on the progression of myopia in children: a literature review. J Am Optom Assoc 1994; 65:117-28.

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