in survival together with reductions in drug toxicities. Major advances, comparable with that seen with the initial empirical use of combination chemotherapy in Hodgkin's disease, are not likely for these tumours in the foreseeable future, and responsible clinicians should evaluate available studies critically and give support to those with adequate controls. New drugs will be developed, but for most patients with advanced solid tumours chemotherapy is not indicated as a routine practice.

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Regular Review

Contact lenses

MONTAGUE RUBEN

The development of contact lenses has been a stimulus to researchers in several disciplines. Certain aspects of corneal physiology have become known only because the contact lens was the initial stimulus to further research. For example, the corneal intake of oxygen in different conditions has now been measured.[1] This has been achieved by placing a polarographic probe on the cornea, with and without a contact lens in situ, at different oxygen tensions.[2-4] The pressure of oxygen in the atmosphere at sea level is 155 mm Hg, but with a lens on the eye it is now known that the tension may be reduced by a quarter or more. Yet the normal cornea can manage on these low tensions even in some instances with the lids closed. Such experiments with corneal hypoxia show how adaptable the human epithelial cell is, but further evaluation is needed to show whether or not prolonged hypoxia will eventually damage these cells. The deeper tissues of the cornea can withstand hypoxia much more readily than the brain, because the cells are not particularly specialised and normally use anaerobic metabolism for their energy requirements. Axiomatically the lowest possible oxygen tension that epithelium could become adapted to without undue long term ill effects would be the lowest level acceptable for the contact lens. Experimental evidence suggests that extremely thin contact lenses which are highly permeable to oxygen lead to tensions of 50 mm Hg at the interface of the cornea and lens and only one third of this when the eye is closed.[5] This is worrying because, although oxygen tensions as low as 100 mm Hg are acceptable,[6] pressures below 20 mm Hg cause changes within the cornea.[7] The question remains unanswered whether the integrity of the epithelium is jeopardised if subjected to lower than normal oxygen pressures for long periods.

Tears and lens wear

An important factor determining a patient's tolerance of contact lenses is the quality and quantity of his tears. The quantity of tears is regulated by reflex action,[8 9] but quantitative aspects such as the concentration of protein in the tears depend on the tissues of the eye surface and vary between one and another individual.

Most people who wear contact lenses experience a drying of the surface of the lens at one time or another. This denatures the protein in the tear film on the lens. Heating the lens without removing the tear film causes further damage and leads to progressive loss of wetting of the lens surface. This is often the cause of intolerance to the lens. There are several "wetting drop" preparations available which help to reduce this effect. Unfortunately, once the lens has been spoilt in this way deproteinisation of its surface may not solve the problem.

Lenses may also cause chronic conjunctival problems.[10 11] Since tears are essential to the successful use of contact lenses it is important to ensure that prospective wearers have normal tear production.

Conventional tests such as Schirmer's test measure only reflex lacrimation, and results of tests done without proper control are often misleading. It is important to know whether reflex tear production does occur, for little or absent secretion may be associated with systemic disease. Thus all patients should undergo a Schirmer's test, and eye movements must be encouraged during the three to five minutes that the paper is in position. With normal conjunctival and corneal sensation, a stimulus should lead to 18 to 20 mm of wetting of the paper in most people.

Some practitioners will not prescribe contact lenses for patients with dry eyes, yet, paradoxically, this condition may be treated successfully with soft contact lenses.[12 13] The symptoms of dry eye are caused by superficial irritation of the cornea and eyelid. Provided that the soft lens can be kept wet with artificial tears, the irritable eye surfaces benefit from the smooth plastic lenses. Similarly, trichiasis and symblepharon are complications of the dry eye which may be alleviated by wearing soft lenses. But if a firmer lens is used without supplementary tears this method is ineffective, and may explain why some practitioners are reluctant to recommend contact lenses for their patients with dry eyes.

Spoilt lenses

Contact lenses may be spoilt if the lens surface is allowed to dry out. The soft hydrophilic lens acts as a semipermeable membrane and therefore becomes a repository for crystalloids in the tear film exudates and in the solutions used by the wearer of the lenses.[14] The lens surface may also absorb proteins, biological contaminants, and micro-organisms.[15] Disinfection and cleaning of the lens will thus greatly affect its useful life. (Such cleaning is likely to remain important until cheaper, mass produced lenses are available.) Hard lenses are also prone to damage, but the changes are chiefly those of deterioration of the edge and surface of the lens. Occasionally the lens warps and its optical properties are therefore lost. Warpage and distortion are also seen with soft lenses and are more common than previously thought. This is because increasingly thin lenses are being produced, and the elastic properties of some materials deteriorate with age. From every viewpoint there is a need for a disposable lens—one that will be worn for one or two months only and is readily available on prescription.

Hygiene

Present regulations of the Department of Health and Social Security and guidelines indicate that the preparation to be used with contact lenses should be safe and efficient and should avoid the problem of infection by micro-organisms including fungi. Fungi are common contaminants, particularly where water is the solvent, and this form of infection is difficult to control. Organic salts of mercury are usually effective but they may cause toxic reactions and their pharmaceutical make up is not always reliable. Many other chemical disinfectants are available, among which hydrogen peroxide is probably the safest. Daily cleaning and disinfection of contact lenses is important, and patients with scrupulously clean habits are least likely to get conjunctivitis from wearing contact lenses.

Allergy

Intolerance of contact lenses is often blamed on hypersensitivity. Doubtless this is the cause in some patients, but to prove that the hypersensitivity is immunological in origin requires biopsy of the eye tissues for histological evidence of such a reaction.[16 17] Some workers believe that the preservatives in contact lens solutions may be partially to blame, and it is possible that these may act as haptens and that the tear proteins coating the lens form the initial antigen which triggers the autoimmune response.

Atopic subjects are more likely to develop reactions to the lens and chemicals than non-atopic subjects, but whether it is a delayed immune type hypersensitivity response caused by medications or a reaction to a chemical is difficult to prove. Irrespective of whether the intolerance is traumatic, chemical, immunological, or a mixture of all three in origin, the practitioner should avoid prescribing chemicals which selectively bond to proteins and plastics—for example, benzalkonium chloride, chlorhexidine, and thiomersal (organic mercury salt). Lenses which are rinsed in sterile non-preserved saline (or water for hard lenses) before insertion are less likely to cause problems.

Extended wear

One of the strongest arguments in favour of leaving soft or semi-soft lenses on the eye for several days or weeks is that the handling of the lenses is minimised. Furthermore, once the lens is coated with a tear film it is well able to tolerate trauma from both the cornea and eyelids. In some cases, however, prolonged corneal occlusion leads to conjunctivitis and corneal oedema, so that some practitioners restrict extended wear of contact lenses to children and patients with specific eye diseases. The manufacturers' statistics on extended wear are favourable but individual sources maintain that the cornea must, at best, be compromised by wearing such lenses.[18–20] Hard or semi-hard materials with very good gas flow properties are beginning to appear on the market and are currently being assessed for use over extended periods. Initial reports have been favourable but the long term effects from trauma are not yet known.

Hard and soft gas permeable lenses

Most hard lenses are made out of polymethyl methacrylate but in the future this material is likely to be used less, because addition of the Silastic molecule to the acrylate polymer results in a copolymer that has gas permeable properties and is softer than polymethyl methacrylate. No doubt there will be other materials to form yet another generation of gas permeable hard lenses possibly without Silastic. Hard lenses are cheaper and afford better visual acuity than soft lenses, but initial tolerance of the hard lens is poor, with a failure rate of at least 30%, often dropping a further 20% after a period of five years. The soft lens now generally available has poorer optics, a shorter life, and maintenance problems, but it is well tolerated and the initial success rate is over 90%, although the long term drop out rate is difficult to assess. We may thus conclude that the long term failure rate is the same irrespective of the type of lens used.

Presbyopia

Soft lenses and hard lenses are usually designed for single vision and, although either type may be designed to give bifocal or multifocal vision, the failure rate is high. This may be

because we are attempting to fit the multivision contact lens to function like a spectacle lens. Thus the eye and lens have to be in the right place at the right time for reading vision to be possible. When the materials or the lens design changes so that the margins of error in fitting and manufacture are not so critical as they are at present, better results should be obtained.[21–23]

Myopia

Myopia is the main reason for fitting contact lenses. Contact lenses have been used to arrest or reduce myopia, but an evaluation by Binder *et al* suggests that their value in curing or preventing the development of myopia is limited, being at best temporary, for they do not produce permanent changes in the cornea or eye.[24] The axial length of the eye is genetically determined, and contact lenses cannot alter this. Flat fitting contact lenses in children will at most alter the cornea by only one or two dioptres, whereas changes in axial length may produce several dioptres of myopia. (The treatment of myopia by radial keratotomy has had a hearsay reaction worth reporting: some patients subsequently need to wear contact lenses to correct residual refractive errors!)

Since defects in colour vision occur in one in eight males the use of a red contact lens in one eye to achieve better contrast is of potential interest. Unfortunately, the cosmetic effect is poor, although the method is scientifically sound and x chrome hard contact lenses may be prescribed for people with red-green colour blindness.

Adverse effects

Previous publications, anecdotal evidence, and personal experience suggest to me that, although complications may occur in the debilitated, irresponsible, or sick patient using contact lenses, the incidence of morbidity is small in comparison with the number of people who wear these lenses—roughly 20 000 000 in the United States, and 3 000 000 in the United Kingdom. Thus the ratio of benefit to hazard is strongly biased towards benefit. Elderly patients with aphakia may often expect problems in the future with their contact lenses but the current trend in treatment is towards giving such patients lens implants rather than contact lenses, and in the USA three out of five patients with aphakia have lens implants.

Children

Children may be fitted with contact lenses to treat myopia and hyperopia. In my opinion if hyperopia is associated with strabismus, the best treatment is for contact lenses, provided that the parents are able to manage this form of treatment.[25] Most myopic children who change from spectacles to contact lenses experience a freedom of movement and change of emotions for the better. This is not just for cosmetic reasons, because the lens improves their vision and may make the daily challenge of the sports field and play more acceptable, freed from their encumbrance of spectacles.

Of particular interest is the fitting of babies with contact lenses—for example, babies operated on in the first few months of life for congenital cataract and hence rendered aphakic. Provided that the parents cooperate, gas permeable hard or soft lenses which are worn during the day are not too difficult to manage, although it is obviously easier to manage continuous wear. Infection may be a problem since it is very difficult for the parent to judge when a lens needs to be cleaned or a new one fitted. Expert management is therefore the key to success. The value of this form of treatment is hard to assess, but the only alternative is to insert an intraocular implant, and this has the drawback that the power may not remain correct if the eye grows to the normal length. Albinism and nystagmus in infants have also been treated with contact lenses but with inconclusive results.

Conclusions

In conclusion, contact lenses have become an accepted method of correcting vision and are successful in over half of those who elect to wear them for the long term.

The manufacturers have undergone a great deal of rationalisation over the past decade, and it is the big corporations that now control the manufacture of contact lenses and their preparations. Future research and development of contact lenses are likely to come from the laboratories of such large corporations, although independent research at universities and institutes and the observations of practitioners will be important.

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