Induced Myopia Associated with Increased Scleral Creep in Chick and Tree Shrew Eyes

John R. Phillips,1 Mohammad Kbalaj,2 and Neville A. McBrien3

PURPOSE. To investigate the role of scleral creep in the axial elongation of chick and tree shrew eyes with induced myopia.

METHODS. Form-deprivation myopia was induced with a diffusing occluder worn over one eye. Scleral samples from the posterior pole and equatorial regions of myopic, contralateral (control), and age-matched normal chick and tree shrew eyes were loaded in vitro with a force of 5 g for 20 minutes while creep extension was monitored. The elastic behavior of sclera from myopic, control, and normal chick eyes was also compared.

RESULTS. In both chick and tree shrew, posterior and equatorial scleral samples from myopic eyes had significantly (P < 0.05) greater creep extensions than equivalent samples from control and normal eyes (n = 10, each group). Among individual tree shrews the difference in creep rate between the sample from the myopic eye and that from the control eye correlated with vitreous chamber elongation (r = 0.746, P < 0.05) and development of myopia (r = 0.792, P < 0.01) in the deprived eye. No such association was found in the data from chicks. The elastic properties of chick sclera were unaffected in form-deprivation myopia.

CONCLUSIONS. In chick and tree shrew, form-deprivation myopia is associated with increased creep rate of posterior and equatorial sclera. In tree shrew, the correlation between increased scleral creep rate and vitreous chamber elongation in myopic eyes supports the hypothesis that induced changes in the axial length of the mammalian eye are mediated by changes in the creep properties of the sclera. (Invest Ophthalmol Vis Sci. 2000;41:2028–2034)

High degrees of axial myopia can be induced in animals by depriving the eye of form vision during a susceptible period. This procedure is commonly used as an animal model of human myopia.1–5 An unanswered question, both in human myopia and in animal models, is how the sclera participates in the process of eye enlargement. Highly myopic human eyes4,5 and monkey1 and tree shrew6 eyes with induced myopia have thinner than normal sclera with abnormal collagen structure.7–9 In addition, form-deprivation myopia in tree shrew is associated with decreased dry weight of sclera,9 decreased incorporation of precursors into glycosaminoglycans (GAGs),10 decreased GAG content,11 and increased levels of active gelatinase A (an enzyme involved in collagen degradation).12 These findings imply that in the tree shrew, induced myopia is associated with remodeling of the sclera and a net loss of tissue at the posterior pole. However, in chick, the most common animal model of myopia, the picture may be more complex. Chick sclera consists of both an inner cartilaginous layer and a thinner outer fibrous layer that resembles mammalian sclera. The two layers show opposite responses to visual form deprivation. The cartilaginous layer increases in thickness as a result of tissue growth, whereas the response of the fibrous layer resembles that of mammalian sclera during induced myopia.13 Because the fibrous layer becomes thinner, there is little change in the overall thickness of chick sclera.14

A notable common factor associated with form-deprivation myopia in monkey, tree shrew, and chick and with high myopia in humans is that in all of them, the fibrous sclera becomes thinner. However, the significance of scleral thinning is unclear. In human myopia, it was thought that a thin sclera may result from abnormal passive stretching of sclera around the enlarged myopic eye.15 More recent evidence suggests that the biomechanical properties of sclera (elasticity and creep) may play a significant regulatory role in the axial elongation of myopic eyes. Elasticity describes the immediate change in length of a sample of material when a force is applied (i.e., load versus extension). Creep describes the slow, time-dependent extension (or compression) of a sample of material when a constant load is applied (i.e., extension versus time). Studies of changes in the elastic properties of sclera in myopic eyes imply that in the tree shrew at least, the modulus of elasticity (the elastic stiffness of the scleral substance itself) remains unchanged with induced myopia.6,10 The increase in elastic extensibility of scleral samples from myopic eyes in tree shrew6 and human11 may be explained by the fact that scleral samples from myopic eyes are thinner than normal. In contrast to the elastic properties, the creep properties of sclera appear to be modified in concert with induced changes in the axial length of the eye. Siegwart and Norton16 have shown that posterior

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sclera from tree shrew eyes with induced myopia has a higher creep rate than normal, whereas samples from eyes recovering from induced myopia have creep rates below normal levels. Moreover, creep rate appears to be modulated in parallel with increased and decreased rates of axial elongation associated with compensation for a minus-power spectacle lens.\(^6\)

In this study we report on the relationship between the degree of myopia induced by visual form deprivation and the quantitative changes in the creep properties of sclera in the tree shrew. We also report the effect of form deprivation on the elastic and creep properties of chick sclera. The purpose was to investigate whether changes to the biomechanical properties of sclera could play a role in the development of myopia in either species. Results of these experiments have been reported briefly in abstract form.\(^18\)

**METHODS**

**Inducement of Myopia**

Animal procedures conformed to the ARVO Statement for the Use of Animals in Ophthalmic and Vision Research. Fifteen maternally reared tree shrew pups (*Tupaia belangeri*) maintained under a 15:9-hour light–dark cycle were used. Myopia was induced by monocular deprivation (MD) of form vision using a hemispherical translucent occluder (25% transmission) mounted in a goggle.\(^19\) Deprivation began 15 days after eye opening, the beginning of the most susceptible period for inducement of myopia in the tree shrew.\(^20\) Ten tree shrews were monocularly deprived for 12 days, and five more animals were maintained under identical conditions without deprivation to provide age-matched normal scleral samples. Thirty chicks (Rhode-Island cross) maintained under a 12:12-hour light–dark cycle were used. Myopia was induced by MD of form vision using a hemispherical translucent occluder (25% transmission) glued to the feathers around the eye. Twenty chicks underwent MD lasting for 6 days, beginning 1 to 6 days after hatching. Ten more chicks were maintained under identical conditions but without visual deprivation, to provide age-matched normal scleral samples.

Ocular measures were performed in chicks and tree shrews under anesthesia with the head supported in the up-right position with a molded bite bar. Animals were anesthetized intramuscularly (tree shrews, 90 mg/kg ketamine HCl with 10 mg/kg xylazine; chicks, 50 mg/kg ketamine HCl with 3.5 mg/kg xylazine). In tree shrews, cycloplegia was induced with 2 drops 1% atropine administered to each eye 30 minutes before ocular measures were taken. Refractive error was measured by streak retinoscopy and recorded as the mean equivalent positions in each eye. One crossed the posterior pole of the eye in the inferior–superior direction approximately 2 mm from the optic nerve stalk. The other was cut in the inferior–superior direction around the temporal equator. Samples were wrapped in laboratory film (Parafilm M, American National Can, Greenwich, CT) and stored at 4°C before mechanical testing (maximum delay, 2 hours). Scleral thickness was measured at the center of each sample using a purpose-built digital micrometer incorporating a sensitive force transducer.\(^24\) Measures (an average of five) were made at an applied force of 2 g over a contact area of 12 mm\(^2\). The likely tissue compression during measurement was less than 8% (computed using transverse Young’s modulus for bovine and human sclera\(^25\)) but no correction for compression was made to the reported values.

**Testing Elastic Behavior of Chick Sclera**

The procedures and equipment used to measure the elastic behavior of chick sclera were identical with those reported in a previous study of the elasticity of tree shrew sclera.\(^6\) Tissue samples were inserted into the jaws of a testing machine (MTT 160; Diastron, Andover, UK) with a nominal exposed test length of 6 mm but with variable degrees of slack. The true beginning length of each sample (used to compute percentage extension) was determined at the end of each test as the length when the load had reached 0.25 g. Samples were strained to failure at 0.2 mm/min while immersed in silicon oil at 35°C to prevent tissue dehydration.\(^24\) Elasticity (load versus extension) relationships obtained in this way not only reflect the elastic modulus (stiffness) of the scleral tissue itself, but they also depend on the cross-sectional area of the sample under test. To compute the elastic modulus of the scleral tissue, stress-versus-strain relationships were derived from the load-versus-extension data and the thickness and width of each sample (stress = load/cross-sectional area of the sample; strain = change in length/original length of the sample). The elastic modulus corresponds to the slope of the stress-versus-strain relationship. However, for nonlinear stress-versus-strain relationships the secant modulus may be computed as the slope of the secant to the curve,\(^25\) (e.g., between 0 and 0.015 strain).

**Testing Creep Behavior of Sclera**

A modified linear motor\(^22\) was used to apply small, steadily maintained loads to scleral samples and to monitor the resultant extension over time. Samples were gripped as described and immersed in silicone oil at 35°C. Samples from myopic and control eyes were tested in alternate order. The creep behavior of all samples was studied under one set of load conditions; namely, 5 g applied uniaxially for 20 minutes. A 5-g load corresponds to a steady intraocular pressure of approximately 90 mm Hg in the tree shrew eye when calculated using Laplace’s formula.\(^26\) Although this is greater than would be maintained under normal physiological conditions, it produced measurable extension values within a short test period (20 minutes) allowing all four samples from each animal to be tested within 2 hours of enucleation. The 5-g load was applied gradually (0–5 g in 4 seconds) and held constant at 5 g for 20 minutes while sample length was monitored every 2 seconds by a data-acquisition board (PC-30AT; Amplicon Liveline, Brigh-ton, UK). After application of the 5-g load, the rate of change of length of the samples took some time to stabilize. To compute creep rate uncontaminated by this effect, 300 seconds were
allowed to elapse after application of the load. Then creep extension during the period 300 to 1150 seconds after loading was computed as a percentage of the length recorded at 300 seconds after application of the load. Creep rate (percent extension per hour) was computed as the creep extension over the period from 300 to 1150 seconds after application of the load.

**Statistical Analysis**

Analysis of variance and Tukey pairwise multiple comparison tests were used to assess group differences, with \( P < 0.05 \) as the minimum level of significance. Otherwise, paired \( t \)-tests were used to assess data from experimental and control eyes within the same group of animals. The significance of Pearson product–moment correlation coefficients (\( r \)) was tested against zero correlation with the \( t \)-test.

**RESULTS**

**Ocular Effects of Deprivation**

In tree shrews, 12 days of MD beginning 15 days after eye opening induced myopia of \(-11.3 \pm 1.8 \) D (mean \pm SEM, \( n = 10 \)) and vitreous chamber elongation of \(231 \pm 31 \) \( \mu \)m in deprived eyes relative to contralateral control eyes (Table 1). In chicks, 6 days of MD beginning 1 to 6 days after hatching induced myopia of \(-20.3 \pm 1.0 \) D (mean \pm SEM, \( n = 20 \)) and vitreous chamber elongation of \(733 \pm 46 \) \( \mu \)m. Equatorial diameters were also significantly greater in deprived chick eyes relative to control eyes (Table 1). Equatorial diameters were not measured for tree shrews, but previous results\(^27\) have shown a significant increase in equatorial diameter in the tree shrew eye after 12 days of deprivation.

**Hydrated Scleral Thickness**

The thickness of posterior sclera from myopic eyes of MD tree shrews (\(135 \pm 5 \) \( \mu \)m, \( n = 10 \)) was significantly less (\( P < 0.05 \)) than that from contralateral control eyes (\(158 \pm 5 \) \( \mu \)m, \( n = 10 \)) and age-matched normal eyes (\(160 \pm 9 \) \( \mu \)m, \( n = 10 \)). The thickness of posterior sclera from control and normal eyes was not significantly different. We found no correlation between the degree of scleral thinning and the amount of vitreous chamber elongation (or myopia developed) among individual tree shrews. The thicknesses of equatorial samples from myopic, control, and normal eyes were not significantly different. In the chick there were no significant differences in the overall thickness of posterior or equatorial sclera between myopic, control, and normal eyes (Table 1).

**Elastic Properties of Chick Sclera**

Posterior scleral samples from chick eyes had sigmoidal load-versus-extension (elasticity) relationships (upper curves, Fig. 1), whereas equatorial samples showed almost linear relationships (lower curves, Fig. 1). In both cases, the mean load-versus-extension relationships for sclera from deprived eyes were essentially the same as those for sclera from control and normal chick eyes.

**FIGURE 1.** Elastic behavior of chick sclera (means \pm SEM, \( n = 10 \)). The upper (sigmoidal) curves show load-versus-extension relationships for posterior scleral samples from myopic, control, and normal chick eyes. The lower (linear) curves which overlie each other, show equivalent relations for samples of equatorial chick sclera.

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**TABLE 1. Ocular Measures from Monocularly Deprived and Normal Chicks and Tree Shrews**

<table>
<thead>
<tr>
<th></th>
<th>Normal Eyes</th>
<th>Control Eyes</th>
<th>Myopic Eyes</th>
<th>Difference (Myopic – Control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refraction (D)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TS</td>
<td>7.7 ± 0.7</td>
<td>8.4 ± 1.0</td>
<td>-2.9 ± 1.3</td>
<td>-11.3 ± 1.8*</td>
</tr>
<tr>
<td>CH</td>
<td>2.2 ± 0.1</td>
<td>2.3 ± 0.2</td>
<td>-17.9 ± 1.1</td>
<td>-20.3 ± 1.0*</td>
</tr>
<tr>
<td>Vitreous chamber depth (( \mu )m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TS</td>
<td>2823 ± 12</td>
<td>2747 ± 20</td>
<td>2978 ± 23</td>
<td>231 ± 31*</td>
</tr>
<tr>
<td>CH</td>
<td>4954 ± 26</td>
<td>4985 ± 38</td>
<td>5718 ± 66</td>
<td>733 ± 46*</td>
</tr>
<tr>
<td>Equatorial diameter (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CH</td>
<td>11.47 ± 0.04</td>
<td>11.50 ± 0.05</td>
<td>11.84 ± 0.07</td>
<td>+3%*</td>
</tr>
<tr>
<td>Scleral thickness (( \mu )m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TS†</td>
<td>160 ± 9</td>
<td>158 ± 5</td>
<td>133 ± 5</td>
<td>-16%*</td>
</tr>
<tr>
<td>TS‡</td>
<td>125 ± 9</td>
<td>116 ± 10</td>
<td>106 ± 6</td>
<td>-9%</td>
</tr>
<tr>
<td>CH†</td>
<td>104 ± 3</td>
<td>112 ± 2</td>
<td>111 ± 3</td>
<td>-1%</td>
</tr>
<tr>
<td>CH‡</td>
<td>148 ± 5</td>
<td>148 ± 2</td>
<td>153 ± 5</td>
<td>+3%</td>
</tr>
</tbody>
</table>

All data are mean \± SEM. For chick (CH) data, \( n = 20 \); for tree shrew (TS) data, \( n = 10 \).

* Significant difference (\( P < 0.01 \)) between means for myopic and control eye data.

† Posterior pole.

‡ Equatorial region.
The secant modulus (stiffness) of the tissue in each sample was computed as described earlier. Although the secant modulus for chick posterior sclera was approximately twice that for equatorial sclera, there was no significant difference in mean values of secant modulus, or the load at which samples failed (failure load, Table 2) for chick sclera from myopic, control or normal eyes. Chick posterior sclera from normal eyes had a much higher mean secant modulus (15.38 × 10^6 Pa) than that for normal tree shrew sclera (2.72 × 10^6 Pa) tested under identical conditions or human sclera (1.8 to 2.9 × 10^6 Pa).28

**Creep Extension of Chick and Tree Shrew Sclera**

Figures 2A and 2B show typical extension-versus-time behavior of posterior scleral samples from the myopic and contralateral control eyes of a monocularly deprived tree shrew and a chick, respectively. Samples were subjected to a constantly applied load of 5 g for 20 minutes. On application of the load, each sample initially extended rapidly. However, during the first 300 seconds (5 minutes) extension versus time settled to a near-linear relationship. At 20 minutes after application of the load, the final extension of the sample from the myopic eye was greater than that of the equivalent sample from the control eye for all MD animals of both species. Similar results were obtained for equatorial samples in both species. The difference in final extension between samples from myopic and control eyes arose partly because extension in the initial, markedly non-linear phase (i.e., up to approximately 300 seconds) was greater for samples from myopic eyes and partly because the slope of the later, near-linear phase (approximately 300-1150 seconds) was also greater for the myopic eye samples. In the following analyses, we considered extension during the near-linear phase of the relationship to be a stable measure of creep extension.16

To isolate creep extension from the initial shorter-term changes in length, the absolute length of each sample was determined at 300 seconds after the load was applied. Creep extension (300–1150 seconds) was computed as a percentage of this length. Figure 3 and Table 2 show that the mean creep extension of posterior and equatorial samples from deprived eyes was significantly greater (P < 0.05) than that of equivalent samples from control and normal eyes in both species. In both species, the mean creep extension of samples from control and normal eyes was not significantly different (P > 0.16), indicating that MD had no observable effect on the creep properties of sclera in the contralateral eye.

**Relationship between Scleral Creep Rate and Myopia**

Among tree shrews, 12 days of MD produced various degrees of vitreous chamber elongation (range, 78 μm to 375 μm) and myopia (range, −2.7 to −20.0 D) in the deprived eye relative to the control eye. Similarly, in the chick six days of deprivation produced a range of vitreous chamber elongation (49–1109 μm) and myopia (−16.0 to −29.3 D). To investigate whether there was a relationship between the degree of vitreous elongation (or myopia) and the change in the creep properties of the sclera in myopic eyes, we plotted least-squares linear regressions for the difference in vitreous chamber depth between the two eyes (deprived minus control) versus the

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**Table 2. Biomechanical Properties of Sclera from Monocularly Deprived and Normal Chicks and Tree Shrews**

<table>
<thead>
<tr>
<th></th>
<th>Normal Eyes</th>
<th>Control Eyes</th>
<th>Myopic Eyes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chick</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failure load (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior pole</td>
<td>59 ± 4</td>
<td>67 ± 5</td>
<td>56 ± 4</td>
</tr>
<tr>
<td>Equatorial region</td>
<td>52 ± 3</td>
<td>50 ± 3</td>
<td>50 ± 3</td>
</tr>
<tr>
<td>Secant modulus (Pa × 10^6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior pole</td>
<td>15.38 ± 1.37</td>
<td>11.56 ± 0.84</td>
<td>12.26 ± 1.56</td>
</tr>
<tr>
<td>Equatorial region</td>
<td>5.70 ± 0.47</td>
<td>6.85 ± 0.45</td>
<td>6.35 ± 0.65</td>
</tr>
<tr>
<td>Creep extension (%)</td>
<td>0.21 ± 0.03</td>
<td>0.16 ± 0.02</td>
<td>0.34 ± 0.04*</td>
</tr>
<tr>
<td>Posterior pole</td>
<td>0.44 ± 0.03</td>
<td>0.41 ± 0.05</td>
<td>0.65 ± 0.09*</td>
</tr>
<tr>
<td>Equatorial region</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tree shrew</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creep extension (%)</td>
<td>0.28 ± 0.05</td>
<td>0.28 ± 0.05</td>
<td>0.55 ± 0.08*</td>
</tr>
<tr>
<td>Equatorial region</td>
<td>0.27 ± 0.02</td>
<td>0.30 ± 0.03</td>
<td>0.55 ± 0.11*</td>
</tr>
</tbody>
</table>

All data are mean ± SEM; n = 10 for both chick and tree shrew data.

* Significant difference (P < 0.05) between means for myopic and control eye data.

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**Figure 2.** Extension-versus-time records for posterior scleral samples from the myopic eye compared with that for the equivalent sample from the contralateral (control) eye. (A) Data for one MD tree shrew and (B) one MD chick. Each sample was subjected to a constantly applied load of 5 g for 20 minutes.
difference in creep rate between scleral samples from deprived and control eyes for each animal (Fig. 4A). Creep rate was computed as percent extension per hour, as described earlier. For tree shrew data there was a correlation between the difference in the vitreous chamber depth of deprived and control eyes and the difference in creep rate of samples from the two eyes (Pearson, $r = 0.746$, $P < 0.05$). Figure 4B shows that there was a similar relationship ($r = 0.792$, $P < 0.01$) between the difference in refractive error of the deprived and control eyes (i.e., the relative myopia of the deprived eye) and the difference in creep rate of samples from the two eyes. A weak association ($r = 0.452$, $P < 0.2$) was found between vitreous elongation and creep rate difference of the equatorial sclera for the tree shrew (not shown). In contrast, no equivalent associations ($r < 0.1$) were found within the chick data (Figs. 4C, 4D).

**DISCUSSION**

**Tree Shrew Sclera**

The primary finding of this study is that in monocularly deprived tree shrews the amount of axial elongation and associated myopia that developed in the deprived eye relative to the control eye was correlated with the difference in creep rate of posterior scleral samples from myopic and control eyes. Although such a correlation does not demonstrate a causal relationship between altered creep properties and axial elongation of the eye, our results provide further support for the hypothesis that changes in the axial length of the eye associated with induced myopia are mediated by regulation of the creep properties of the sclera.

Scleral samples from myopic tree shrew eyes were significantly thinner than those from control and normal eyes. This reduced thickness may itself have accounted for the increased creep rate of sclera from myopic eyes. To investigate the significance of this reduced thickness, a predicted creep extension of each control eye sample was computed assuming that its thickness was reduced to that of the sample from the myopic eye of the same animal. For posterior scleral samples, the mean creep extension of myopic eye samples was significantly greater ($P < 0.01$) than that predicted for control sclera of similarly reduced thickness. Based on this analysis the increased creep extension of myopic eye sclera that was observed experimentally cannot be accounted for on the basis of scleral thinning. This implies that changes to the material properties of the scleral tissue itself far outweigh the changes in scleral thickness in determining the increased creep rate in myopic tree shrew eyes. These findings are in keeping with previous reports of remodeling of the scleral extracellular matrix during axial myopia development. The reduction in the synthesis$^{10}$ and content$^{11}$ of GAGs in the tree shrew sclera would be expected to result in a reduction in scleral hydration and therefore in scleral thickness, because these long polysaccharide chains have a high-density negative charge that mediates the passage of water through the extracellular matrix. More important, altered hydration and GAG content in other tissues (e.g., cartilage$^{29}$ and skin$^{30}$) are associated with altered mechanical properties of the tissue, as found for sclera in the present study.
We have shown that the overall hydrated thickness and the elastic properties of chick sclera retain their normal values when high levels of form-deprivation myopia and associated axial elongation are induced in the chick eye. Because induced myopia in the chick is not associated with elevated mean intraocular pressure, our results imply that simple elastic stretching of the sclera cannot account for the axial elongation observed with induced myopia in the chick. A similar conclusion was reached in two studies of the elastic properties of sclera in experimentally induced myopia in the tree shrew.

In the present study, form-deprivation myopia in the chick was associated with a significant increase in creep rate of posterior and equatorial scleral samples from myopic eyes. This increase in creep rate must be accounted for either by changes in the material properties of the sclera or by the changes in the relative thickness of the cartilaginous and fibrous layers that are known to occur in form deprivation myopia in the chick, or both. However, the significance of increased creep rate in sclera from MD chick eyes is difficult to assess. We found no association between the amount of axial elongation that developed in the deprived eyes of individual MD chicks and the difference in the creep rate of the scleral samples from their myopic and control eyes.

**Chick Sclera**

Siegwart and Norton have demonstrated a temporal correspondence between axial elongation rate of the eye and scleral creep rate. They have shown that in the tree shrew, scleral creep rate increases and decreases in concert with increases and decreases in axial elongation rate. In the present study we recorded a significant increase in creep rate in scleral samples from both the posterior pole and the equator in both chick and tree shrew. Thus, there was a spatial correspondence between the loci of scleral expansion and increased creep rate. Finally, in tree shrews, we have demonstrated a magnitude correspondence between the amount of vitreous elongation (and the amount of myopia developed) and the amount by which scleral creep rate differs in the myopic and control eye. We believe that the correspondence of changes in eye size with changes in scleral creep rate across time, spatial locus, and magnitude provide strong support for the hypothesis that induced changes in the axial length of the mammalian eye are mediated by regulation of the creep properties of the sclera.

**Correspondence of Creep Change with Eye Expansion**

Siegwart and Norton have demonstrated a temporal correspondence between axial elongation rate of the eye and scleral creep rate. They have shown that in the tree shrew, scleral creep rate increases and decreases in concert with increases and decreases in axial elongation rate. In the present study we recorded a significant increase in creep rate in scleral samples from both the posterior pole and the equator in both chick and tree shrew. Thus, there was a spatial correspondence between the loci of scleral expansion and increased creep rate. Finally, in tree shrews, we have demonstrated a magnitude correspondence between the amount of vitreous elongation (and the amount of myopia developed) and the amount by which scleral creep rate differs in the myopic and control eye. We believe that the correspondence of changes in eye size with changes in scleral creep rate across time, spatial locus, and magnitude provide strong support for the hypothesis that induced changes in the axial length of the mammalian eye are mediated by regulation of the creep properties of the sclera.
References