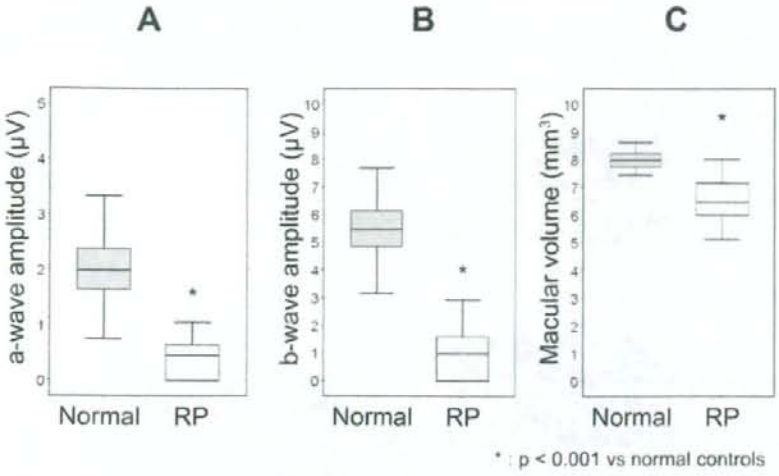

FIGURE 3. Box plots of the a- and b-waves of the fmERGs and total macular volume for normal controls and patients with RP. Line within the box indicates the median, the box the 25 and 75 percentiles, and the end of the error bars the 2.5 and 97.5 percentiles.

(IS/OS line) as a measure of the structural integrity of the macular area.

The amplitudes of the fmERG for the three RP groups classified by the length of the IS/OS line are shown in the upper traces of Figure 5 (see also Fig. 1). The amplitudes of the fmERGs in type 1 patients with RP (distinct IS/OS line over the central 2 mm) were significantly larger than those in type 2 (distinct IS/OS line only in the central 2 mm) and type 1 (absent IS/OS line) patients with RP ($P < 0.05$). Nine (81%) of 11 patients with type 3 RP had nonrecordable fmERGs, whereas none with type 1 had nonrecordable fmERGs (Fig. 5, bottom plot). These findings suggest that the patients with RP with longer IS/OS lines had larger fmERG amplitudes.

However, we found that the correlation between the amplitude of the fmERGs and changes in the OCT image was weak, even when the integrity of the IS/OS line was used to separate the patients with RP into the three groups. The weak correlation was probably due to two factors: first, there was no statistically significant difference in the fmERG amplitude between types 2 and 3 ($P = 0.07$ for a-wave; $P = 0.20$ for b-wave); and second, there was a large variation in the amplitudes of the fmERGs in type 1 and some patients had severely reduced amplitudes (Fig. 5, bottom plot).

Patients with RP with Normal Macular Volume but Severely Reduced fmERGs

Finally, we wanted to investigate whether the IS/OS line was preserved in our four patients with normal macular volume and severely reduced fmERG amplitudes (Fig. 4). We expected that even though the total macular volume was within the normal range, these patients may have had a very short IS/OS line, which may be the reason for severely reduced mfERG. The gray-scale OCT images and the waveforms of fmERG in four patients with RP who had normal macular volume and severely reduced fmERG amplitude (patients 4–7) are shown

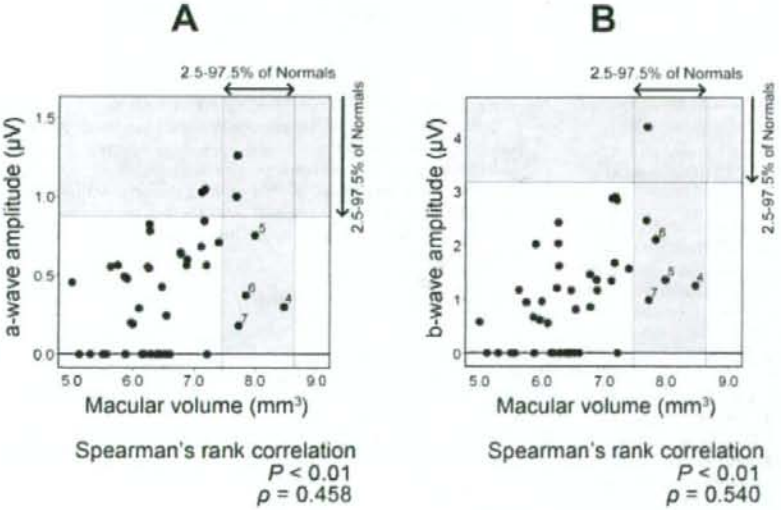

FIGURE 4. Amplitudes of a- and b-waves plotted against total macular volume in 43 patients with RP. There is a weak but significant correlation between the fmERG amplitude and total macular volume. There were four patients with RP who had normal macular volume but severely reduced fmERG (patients 4–7). *Shaded area*: the 2.5 to 97.5 percentiles of total macular volume and mfERG amplitude in age-similar normal subjects.

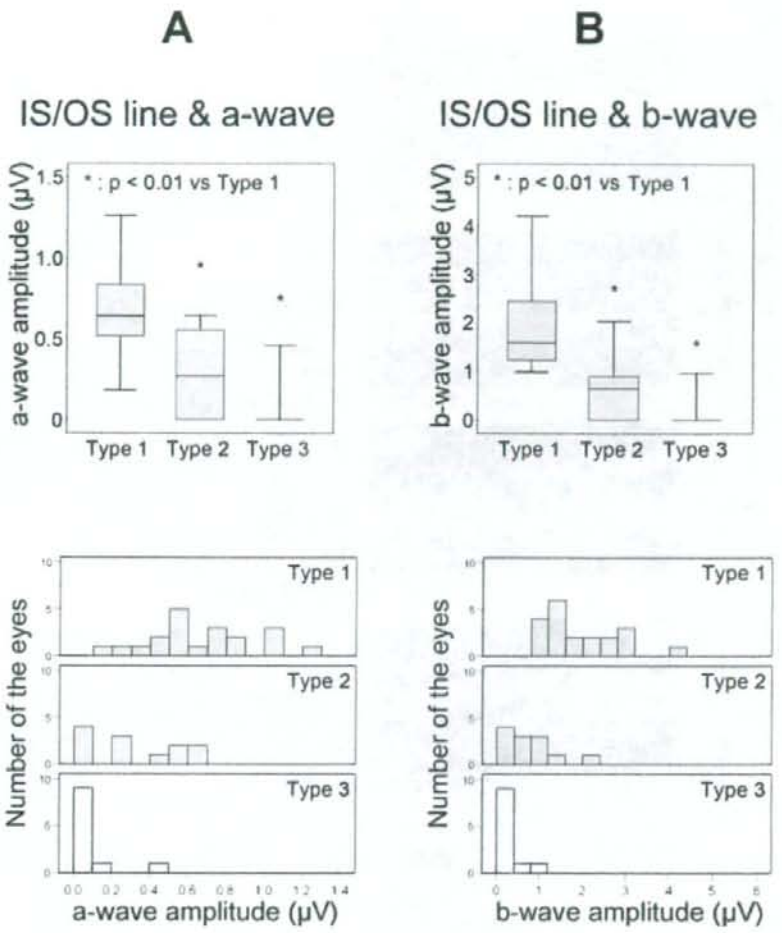

FIGURE 5. The (A) a- and (B) b-wave amplitudes of the fmERGs for patients with RP with the three types of IS/OS line configuration (see also Fig. 1). *Top*: The fmERG amplitudes in type 1 patients with RP were significantly larger than those in type 2 or 3 patients with RP. *Bottom*: histograms of the fmERG amplitude for three types of patients with RP.

in Figure 6. Against our expectations, the length of IS/OS line was relatively well-preserved (>4 mm) for these four patients, and was more than 5 mm for three patients (patients 4, 5, and 7). These results indicated that there are some patients with RP whose total macular volume and the length of IS/OS line were relatively well preserved in the macular area, but their electrophysiological function within this area was severely affected.

DISCUSSION

Our results demonstrated that there was a significant correlation between the amplitudes of the a- and b-waves of the fmERG and the total macular volume in our 43 patients with RP. These results were not surprising because the gradual thinning of the retina caused by the shortening of outer segments and the loss of photoreceptors should result in the reduction of the fmERG amplitude in the retina of patients with RP. The results of an earlier study on the correlation between the retinal histopathology and ERG findings in an animal model of RP support this idea.[52]

Although there was a significant correlation between the amplitude of the fmERG and total macular volume, the degree of correlation was weak: the coefficient of correlation (ρ) was only 0.46 for the a-wave, and 0.54 for the b-wave. One of the major reasons for this weak correlation was that there were four patients with RP who had normal macular volume but severely reduced fmERG amplitudes (Fig. 4). In contrast, there were no patients with RP who had normal fmERG amplitude but severely reduced total macular volume. These results indicate that a normal total macular volume does not guarantee normal electrophysiological function of the macula in patients with RP.

We initially reasoned that the weak correlation might be because we used total macular volume as a measure of macular structure. It is well known that the early histopathologic changes in eyes of patients with RP were mainly a shortening or distortion of the rod and cone photoreceptors.[6–8] Thus, we next investigated whether the structural integrity of the IS/OS junction (i.e., the length of the IS/OS line) correlated with the amplitude of the fmERG. As shown, the length of the IS/OS line generally correlated with the fmERG amplitude. However, the correlation between the length of IS/OS line and the fmERG amplitude was also weak. Careful examinations of the OCT images and fmERG records in individual patients with RP

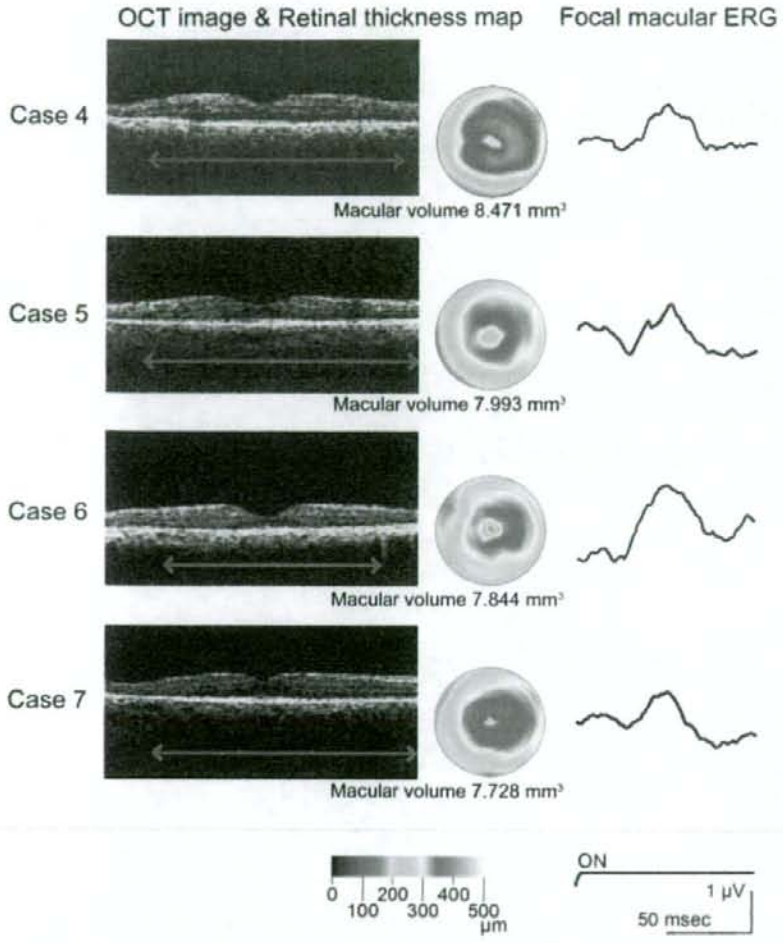

FIGURE 6. Gray-scale OCT images and fmERGs recorded in four patients with RP who had normal macular volume but severely reduced fmERG (see also Fig. 4). *Red lines*: the length of detectable IS/OS lines on the gray-scale OCT images. The amplitudes of fmERGs were severely reduced in all four patients, but the length of the IS/OS line was more than 4 mm in all patients and was more than 5 mm in three of five patients.

showed that there were four patients with RP who had normal macular volume and a relatively long IS/OS line, but severely reduced fmERG amplitudes (Fig. 6). Of interest, three of these four patients had a detectable IS/OS line longer than 5 mm. These results indicated that there are some patients with RP whose macular OCT images are relatively well preserved, but their electrophysiological functions are severely reduced.

The exact reason that some patients with RP had a preserved macular OCT image but severely reduced fmERG was not determined. There are two possibilities: First, these patients may have very subtle structural changes, but our OCT system (third-generation Stratus OCT) may not have detected the changes. For example, using ultrahigh-resolution OCT, Witkin et al.[30] measured the distance between the IS/OS line and the outer border of the retinal pigment epithelium thickness (called FOSPET), and demonstrated an excellent correlation between visual acuity and FOSPET in nine patients with RP. In our study, we were able to measure the length of the IS/OS line, but could not obtain reliable measurements of FOSPET in our OCT images. New-generation, high-resolution OCT instruments may enable us to make these measurements.

A second possibility is that the functional abnormality may precede structural changes in the macula of some patients with RP. It was recently demonstrated that some patients with Leber congenital amaurosis (LCA), the most common inherited cause of blindness in childhood, can retain the cone photoreceptors and inner retinal architecture in the central retina, but have severely reduced central vision at a relatively early stage of the disease.[29,31] If this second possibility is correct, the combined assessment of macular structure by OCT and macular function by psychophysics or electrophysiology can provide important information on the macula of patients with RP.

There are some limitations in our study. First, we planned to measure the volume of the inner, middle, and outer retinal layers separately and wanted to examine the correlation between the volumes in each layer and the fmERG amplitude. This comparison was possible in normal subjects, but was difficult in patients with RP with severely reduced macular thickness. Recent advances in new ultrahigh-resolution OCT technique may enable analysis of the thickness of each retinal layer, and this will allow us to investigate the changes in each retinal layer after photoreceptor degenerations. Second, we investigated the correlation of macular volume with the fmERG amplitude, but did not study the correlation with the implicit time, because there were many patients with RP whose amplitude of fmERG was so reduced that the implicit time could not

be measured precisely. However, the correlation between the implicit time and OCT images may be interesting, because the results of past studies have shown that the delay in the implicit time of focal ERGs can be another important indicator of functional changes in the macula area of patients with RP.[14–19] Third, we did not record the OCT and mfERGs from the same patient at different time points, and thus cannot examine the longitudinal progression of the changes in patients with RP.

In conclusion, we studied the correlation between the fmERG amplitude and macular structure by OCT and found that there was a significant correlation between these two measures, but the degree of correlation was weak. One major reason for this low correlation was the presence of some patients with RP who had well-preserved macular OCT images but severely reduced fmERGs. Although the exact mechanism for this discrepancy needs further investigation, we believe that the combined examination of macular structure by OCT and macular function by fmERG can provide important information on the pathophysiology, prognosis, and future treatments in patients with RP.

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液晶視力表　システムチャート SC-2000の臨床評価

Clinical evaluation of liquid crystal displayed visual acuity test "System chart SC-2000"

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【要約】 日常診療では種々の視力表が用いられている．しかし，それらは視標背景の輝度のばらつきが大きく，また，標準化されているとはいえない．今回，プロトタイプの液晶視力検査装置がニデック社によって作製された．我々は，①液晶視力表システムチャートSC-2000®と従来の視力検査装置の視力の比較と，②SC-2000の液晶モニターを斜めから見たときの視力への影響の２点から臨床的に評価した．

その結果，SC-2000は，従来から用いられている准標準視力検査装置と有意差なく，相関のある視力結果が得られた．視標正面から15°以内の測定位置のずれであれば，正面から見ているのと同等の視力が得られた．ハロゲンランプを光源とし，１視標につきランプ１つか２つで後方から照らす従来の視力検査装置に比べ，安定した条件で検査が可能であり，多施設で視力の比較をする場合，共通の視力検査装置として使用可能であると考えた．

【キーワード】 液晶視力検査装置，准標準視力検査表，液晶モニター，背景輝度，視力

緒言

我が国で用いられている視力検査装置は，標準視力検査装置と准標準視力検査装置，特殊視力検査装置の３種類に分けられる．JIS規格の中で，標準視力検査装置は，輝度が80～320cd/m^2，コントラストが74％以上で，視標には８方向のランドルト環を用いることが必要と規定している．また，視力値の段階はlog MARステップを用い，視標の精度は1.6までは標準値の±5％，2.0は±10％以内であるほか，最小視標数，視標相互の間隔なども細かく規定され，視標の背景は均一で明るく見えること，という条件がついている．准標準視力検査装置は，遠距離視力検査用に作製されたもので，ランドルト環およびランドルト環と相関づけられた視標を用い，実用性に重点をおく装置とされている．視標の精度は標準値の±10％以内である．また，特殊視力検査装置は，近距離視力検査装置，字ひとつ視力検査装置，スクリーニング用視力検査装置，両眼開放視力検査装置，光学式視力検査装置などを含み，ランドルト環およびランドルト環と相関づけられた視標を用いた装置である．精度は准標準視力検査装置と同じく±10％以内であるが，同一段階の視標数に特に定めはない[1-3]．これに従うと日常診療で広く用いられている視力検査装置は，准標準視力検査装置と特殊視力検査装置である．

我々は，液晶モニターの特徴を調べるために，従来使用している准標準視力検査装置を用い，視標の背景輝度の比較を行った．図１に示すように，0.1の視標の周囲５ヵ所を選択して，液晶モニターおよび従来型の２機種の准標準視力検査装置を比較した．視標の背景輝度のばらつきは，従来の背景照明を用いる視力検査装置では大きく，液晶モニターでは小さいことが明らかであった(表１)．

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図1　背景輝度の測定場所
0.1の視標の周囲5ヵ所を，液晶モニターおよび従来型の2機種の准標準視力検査装置で測定した．

表1　視力表による背景輝度の比較

	a	b	c	d	e
液晶視力表（実験機）	299.5	284.6	281.6	294.8	293.7
A社製：准標準視力検査表	328.5	214.8	201.4	231.7	210.3
B社製：准標準視力検査表	337.8	239.9	227.1	217.7	230.9

米国を中心とした弱視に関する多施設共同研究では，コンピュータで制御された視標をCRTあるいは液晶モニター上に表示する電子視力検査装置が開発され，研究のための共通の検査装置として用いられている．一方，我が国では，そのような視力検査装置が研究目的で用いられているものの市販はされていない．そのため，標準化された視力検査装置が必要であると考えた．コンピュータ制御を行うことで，1つのモニターで，准標準視力検査だけでなく，字ひとつ視力検査，字多数視力検査，コントラスト感度検査といった様々な視力評価を行う可能性がでてくる．近年の液晶モニターの高輝度化，および価格低下によって，液晶モニターを用いた視力検査装置の普及の可能性が高くなった，我々はその開発に協力をしてきた．

今回，プロトタイプの液晶視力検査装置がニデック社によって作製されたため，使用上の問題点を探るために以下の検討を行った．

①液晶視力表 システムチャート SC-2000®（以下；SC-2000）と従来の視力検査装置の視力の比較と，②SC-2000の液晶モニターを斜めから見たときの視力への影響の2点から臨床的に評価したので報告する．

対象および方法

SC-2000の液晶モニターは，19インチ（高解像度SXGA液晶），解像度1280×1024，1ドットが0.294×0.294mmであり，動作は産業用マイクロプロセッサーで行われる．視標は，0.03～0.05までは1つ，0.06～0.08までは2つ，0.1，0.15は3つ，0.2より小さい場合には5つ，が同時に1画面に提示される．視標は小数視力を用いている．提示はリモートコントロールによって変化させることが可能である．

1．SC-2000と従来の視力検査装置との視力の比較

視標の表示方法は，SC-2000ではモニターに提示可能な視標数に制限があるため，今回の比較では字ひとつ表示を用いた．比較に用いた検査装置には，従来から広く用いられている字づまり表示のA社製准標準視力検査装置を使用した．これは，視標を，A12V，5Wのハロゲンランプで後方から照らすものである．

対象は，屈折異常以外に眼疾患のない20～50歳の成人20名40眼と，浜松医科大学眼科通院中で，同日に2機種での視力検査に協力が得られた，5～10歳の小児14名28眼とした．

測定方法は，集中力・疲労といった検査の順による視力への影響を考慮し，成人・小児とも半数ずつ，検査の順を変え測定した．検査距離5mで，同一検者が自覚的レンズ交換法による完全屈折矯正を行い測定し，60％以上の正解を視力値とした．そして2機種間での比較をWilcoxonの符号順位和検定で行い（$p < 0.05$を有意差あり），さらに，相関を検討した．検査室の明るさは，JIS規格の遠距離視力検査方法の条件内であった．

2．SC-2000の液晶モニターを斜めから見たときの視力への影響

対象は，屈折異常以外に眼疾患のない成人5名10眼とした．

測定方法は，検査距離3mとし，視標サイズはその距離に設定変更して行った．そして，**図2**に示すように，液晶モニター正面を0°とし，モニター面に対して水平に5°間隔で15°までの4ヵ所で，同一検者が自覚的レンズ交換法による完全屈折矯正を行い測定し，60％以上の正解を視力値とした．このとき，15°の位置は正面0°の位置より約0.9m離れた位置となる．

表2　液晶モニターを斜め方向から見たときの視力の変化

症例	1		2		3		4		5	
	R	L	R	L	R	L	R	L	R	L
0°	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.2	1.2
5°	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.2	1.2
10°	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.2	1.2
15°	1.5	1.2	1.5	1.5	1.5	1.5	1.5	1.5	1.2	1.0

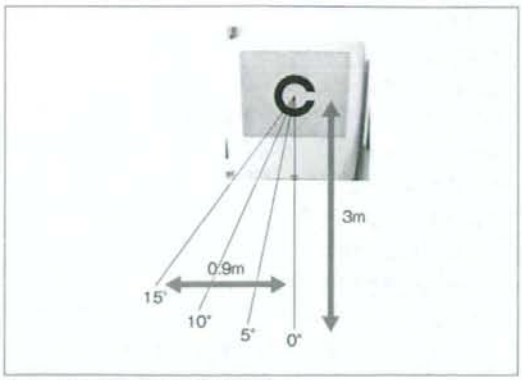

図2　斜め方向からの視力の測定場所
液晶モニター正面を0°とし，モニター面に対して水平に5度間隔で15°までの4ヵ所で視力を測定した．検査距離3mで，15°の位置は正面0°の位置より約0.9m離れた位置となる．

結果

1．SC-2000と従来の視力検査装置との視力の比較

成人および小児の，SC-2000とA社製准標準視力検査装置で得られた視力値を図3,4に示す．視力は，得られた小数視力値をlog MAR換算して用いた．

成人の視力は，換算log MAR値平均が，SC-2000では−0.126，A社製准標準視力検査装置では−0.119であった．2機種で視力値に1段階の差のあったのは，成人40眼中6眼，小児28眼中10眼であった．2段階以上差のあったものはなかった．SC-2000のほうが，視力不良の症例が多い傾向がみられたが，統計学的には2機種間で有意差はなく相関性のある結果が得られた（相関係数0.962，$p < 0.0001$）．

小児の視力は，換算log MAR値平均が，SC-2000では−0.088，A社製准標準視力検査装置では−0.086であり，2機種間に有意差はなく高い相関を認めた（相関係数0.8705，$p < 0.0001$）．

2．SC-2000の液晶モニターを斜めから見たときの視力への影響

液晶モニター正面0°～15°までの4ヵ所での視力の変化を表2に示す．5名10眼中，2名2眼で，正面から15°移動した位置で初めて1段階の低下がみられたが，それ以外の変化はみられなかった．

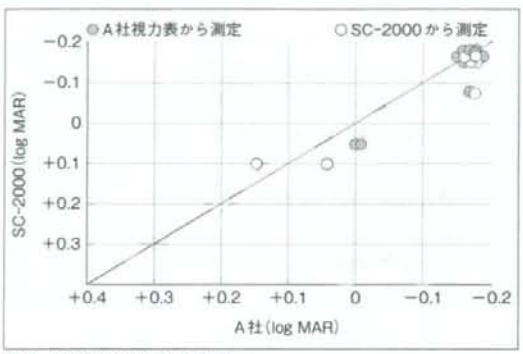

図3　2機種間の視力比較（成人）

考按

1．SC-2000と従来の視力検査装置との視力の比較

2回の視力検査を同日に行うことは，常に検査の順番の影響を考慮しなくてはならない．また，検討を行ったSC-2000と従来の視力検査装置では，視標の提示方法が異なるために，全く同じ結果が得られるとは限らない．そこで，さらにこの2点について考察を加える．

2機種間で視力差があったものを，検査を行った順で

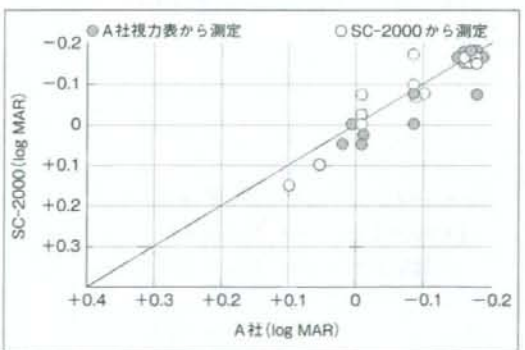

図4　2機種間の視力比較（小児）

検討すると，後で行った視力検査のほうが不良だったものは，成人40眼中4眼(10％)，小児28眼中6眼(21％)，先に行った検査のほうが不良であったのは，成人40眼中2眼(5％)，小児28眼中4眼(14.6％)であり有意ではなかった．検査の順番が視力検査に影響を及ぼしたと思われる被検者もあるが，全体の結果に影響を与えるほどではなかった(成人；$p=0.18$，小児；$p=0.12$)．

視標の提示方法では，SC-2000では字ひとつ表示，准標準視力検査表では字づまり表示であることが問題になる可能性がある．特に8歳頃までcrowding現象がみられるとされる小児の視力を測定する上で重要になると考えられた[4]．しかし，平均視力の差は成人より小児のほうが小さく，crowding現象が結果に影響したとは考えにくい．

2．SC-2000の液晶モニターを斜めから見たときの視力への影響

小児が対象の場合には，検査中，頭を動かすなど液晶モニターを斜めに見ることが懸念される．被検者の頭位ずれによるモニター面に対する視線の角度は，検査距離が短いほど大きくなる．今回の検討で，3mの距離で15°の位置まで視力結果に変化がみられなかったことから，通常の検査条件の範囲であればその影響は少ないと考えられた．

今回の検討では，比較的視力の良い被検者のみを対象としたため，検査装置間での視力の差が明らかにならなかった可能性が残る．液晶視力検査装置は0.03までの低視力用の視標が表示でき，モニターと被検者間の距離や視標の提示場所を一定にしたまま測定できるという利点がある．そのため，視力不良な者，中心固不良な者，視野障害のある者で，視標を見つけやすい可能性がある[5]．それによって従来の視力検査と異なる視力値が得られることも考えられ，興味のもたれるところである．

逆に，視標の作成にあたって液晶モニターの本質的な問題が指摘されている．それは，液晶モニターのドット数に限界があるため，印刷されたもののようにスムーズな表示が不可能な点である．特に小さい視標では視標の輪郭に灰色を用いて滑らかに見せる技法を用いているが正確さにかける．一般臨床の場面では問題ないと考えるが，高視力者の視力測定の際問題になる可能性がある．今後は，さらに高解像度のモニターを用いることで，より正確な視標表示が可能になると考える．さらなる改良が期待される．

結論

液晶視力表 システムチャートSC-2000®は，従来から用いられている准標準視力検査装置と相関のある視力結果が得られた．また，視標正面から15°以内の測定位置のずれであれば，正面から見ているのと同等の視力が得られた．

ハロゲンランプを光源とし，1視標につきランプ1つか2つで後方から照らす従来の視力検査装置に比べ，安定した条件で検査が可能であり，多施設で視力の比較をする場合，共通の視力検査装置として使用可能であると考える．

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間欠性外斜視小児の両外直筋後転術

Bilateral lateral rectus muscle recession for intermittent exotropia

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Miho Sato[1*]

【要約】 間欠性外斜視の小児に対する両外直筋後転術の効果を検討した．

1995～2002年に名古屋大学，2002～2006年に浜松医科大学で手術を行った症例のうち，術後3ヵ月以上経過を観察できた47名の術後結果を報告する．うち1年以上経過を追えたものは26例である．年齢の平均は6.5(3～15)歳で，術前近見眼位の平均は32.3pd(12.0～50.0)，遠見眼位の平均は34.0pd(20～50)，術量は各眼平均6.8mm(4.0～8.5)であった．

術後1ヵ月の眼位は，近見4.7(－18～30)pd，遠見6.0(－8～25)pd，3ヵ月後は近見6.6(－20～30)pd，遠見7.7(－14～35)pd，1年後は近見8.7(－25～35)pd，遠見9.3(－25～30)pdであった．20プリズムを超える眼位異常が残ったのは1ヵ月で2/45名，3ヵ月で5/40名，6ヵ月で5/32名，1年で3/26名であった．内斜視が残存した1名は再手術を受けたが，それ以外は斜位を保てるため，再手術とはなっていない．

術前眼位が40プリズム未満のものでは，術後のもどりが少なく，満足のいく結果であったが，40プリズム以上のものでは，術後残余斜視角が大きく，術式や術量に再考が必要であると思われた．

【キーワード】 間欠性外斜視，手術，外直筋後転術，前後転術

緒言

我々は，基礎型および開散過多型外斜視の手術方法として，両眼の外直筋後転術を第一選択として行っている．両外直筋後転術の利点としては，術後の瘢痕形成が少なく，術後の異物感が少ないことが挙げられる．しかし，眼位の矯正については，前後転術に劣るという報告や，術後早期から眼位が安定するという報告があり，一定していない．今回は，1人の術者が行った両眼外直筋後転術の小児症例をレトロスペクティブに検討したので報告する．

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対象および方法

1．対象

対象は1995～2002年に名古屋大学，2002～2006年浜松医科大学で間欠性外斜視に対して両外直筋後転術を行った症例のうち，術後3ヵ月以上経過を観察できたものである．術前の近見立体視がTitmusステレオテストで5/9未満のもの，矯正視力に二段階以上の差があるもの，斜筋手術を同時に受けているものを除外した．その結果，47名が選出された．うち1年以上経過を追えたものは26例である．

2．方法

術前検査は，視力検査，アトロピンまたは塩酸シクロペントラートを用いた調節麻痺下屈折検査，前眼部細隙灯顕微鏡検査，眼底検査，眼位眼球運動検査，立体視検査，両眼視機能検査を行った．術前の眼位検査は交代プ

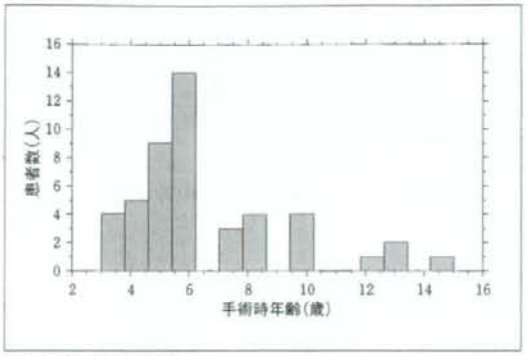


図1　手術時年齢別分布

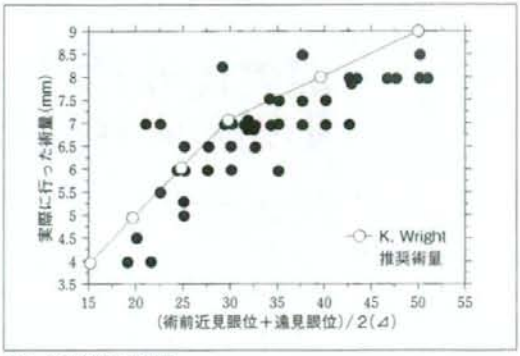


図2　術前斜視角と術量
近見眼位と遠見眼位の中間値を目標とし，推奨値に基づいて手術量を決定したが，年齢が若い症例が多いため，実際には，やや推奨量より少なかった．

リズム遮閉検査を行い，できる限り最大斜視角を引き出すために，片眼遮閉30分，プリズムアダプテーションテスト，超遠方視での眼位測定，＋3D加算した上での近見眼位測定などを適宜組み合わせて行った．手術量は，上記の眼位測定の結果に基づき，遠見眼位と近見眼位の中間値を目標に，Kenneth Wrightの術量[1]を参考にして，両眼に等量の外直筋後転を行った．

結膜切開は輪部切開あるいは，円蓋部切開を行う．輪部切開では，12時と6時の角膜輪部に制御糸をかけ，円蓋部切開では，制御糸は用いずに外直筋を露出する．外直筋露出に際して，前部テノン嚢の剝離は鈍的に行い，外直筋上下の筋間膜を切開するが，外直筋表面と眼窩をつなぐ筋間膜の剝離は最小限とした．外直筋上の血管をバイポーラーで止血した後，両端針の6-0バイクリル糸を外直筋に通し筋付着部で切離する．後転部位をピオクタニンで強膜上にマーキングをした後，通糸して縫合する．結膜を元の位置に戻すか，数mm後転した位置に8-0バイクリル糸で縫合し，手術を終了する．

1995～2001年までは，結膜下にベタメタゾンを注射しエコリシンン眼軟膏を塗布し，両眼に眼帯をした．2002年以降は，副腎皮質ステロイドの結膜下注射を中止，また2005年以降は眼軟膏の代わりに，オフロキサシンまたはレボフロキサシン点眼を行い，術後の眼帯も中止した．

術後は，抗生物質内服，フルオロメトロン点眼，抗生物質点眼を行い，術翌日，1週間後，1ヵ月後，3ヵ月後に診察を行った．

術後診察は，視力検査，屈折検査，近見および遠見での交代プリズム遮閉検査，立体視検査を行った．

結果

手術時年齢の平均は6.5(3～15)歳で，術前近見眼位の平均は32.3pd(12.0～50.0)，遠見眼位の平均は34.0pd(20～50)，術量は各眼平均6.8mm(4.0～8.5)であった．そのうち，遠見斜視角が，近見斜視角より15プリズム以上大きい開散過多型が6名，それ以外は基礎型であった．手術時年齢の分布を**図1**に示す．経過観察中に，斜視の再発あるいは低矯正のために再手術となったものはなく，過矯正となって追加手術を受けたものが1例あった．

小児が対象であったことから，眼球が小さい症例も多く，実際には推奨されていた値よりも，少ない手術量を行っていた．近見斜視角と遠見斜視角の中間値と実際に行った手術量の関係を示す(**図2**)．

術後の1ヵ月，3ヵ月，6ヵ月の眼位を**図3～5**に示す．術後1ヵ月の近見眼位の平均は，4.7pd(－18～30)，遠見眼位の平均は6.0pd(－8～25)であった．術後3ヵ月では，近見眼位の平均は6.6(－20～30)pd，遠見7.7(－14～35)pdとわずかな戻りがみられた．

術前眼位別に術後眼位を提示する(**図6**)．術前眼位が40プリズム未満の症例では，術後6ヵ月間の眼位の戻りがほとんどみられないのに対し，術前眼位が40プリズムを以上の症例では，術後6ヵ月まで徐々に眼位の戻りがみられた．術後3ヵ月目における，後転量に対する斜視角の矯正効果は，術前眼位25プリズム未満の場合，後転1mmあたり1.5プリズム，25プリズム以上では後転1mmあたり2.0プリズムであった．

図3　術前眼位と術後1ヵ月の遠見眼位
術前眼位が30プリズム以内のものは全例15プリズム以内に入っていた.

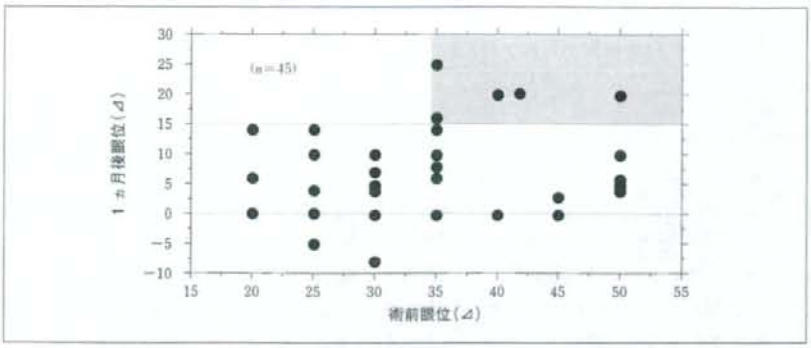


図4　術前眼位と術後3ヵ月の遠見眼位

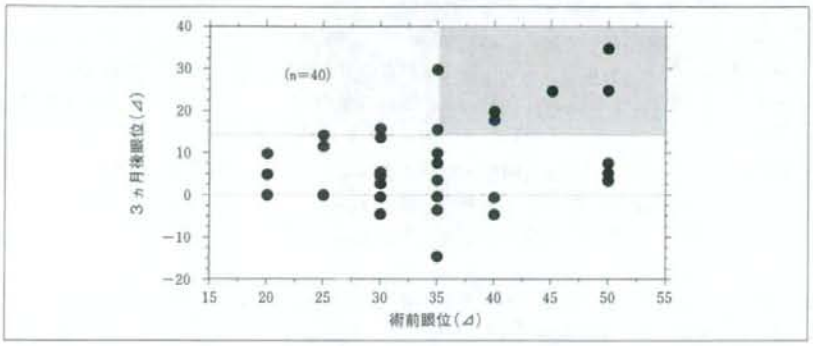


図5　術前眼位と術後6ヵ月の遠見眼位

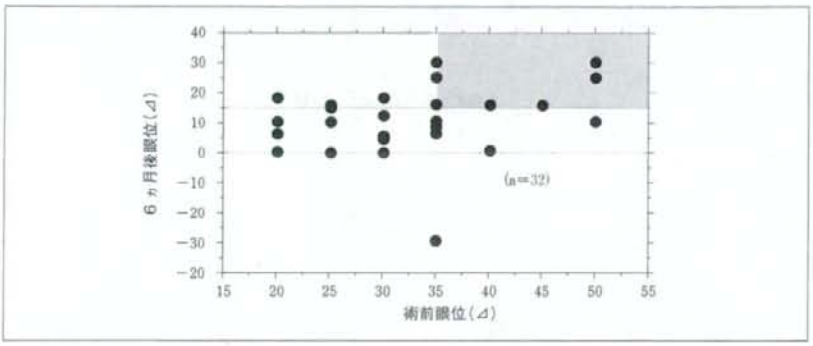
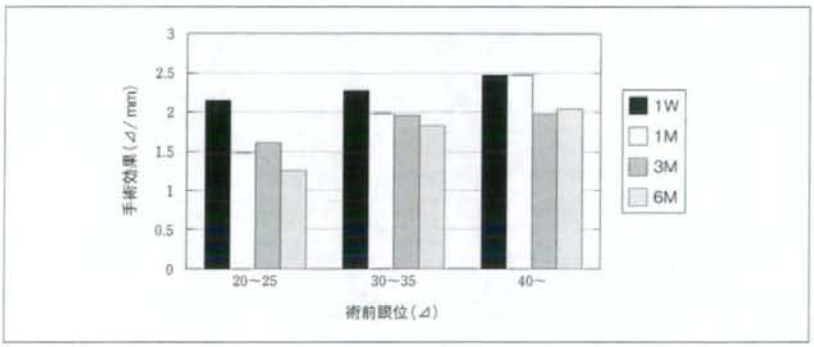


図6　術前眼位別，1mm後転あたりの眼位矯正量
術前斜視角が大きいほど，1mmあたりの矯正量は多くなっていた.



就学前と就学後に手術を受けた場合の，手術効果および術後の戻りには差が認められなかった．

考按

今回の検討では，経過観察期間が短く，長期経過については触れることができないが，術後6ヵ月以内であれば，術前斜視角40プリズム未満の間欠性外斜視では術後斜視の戻りが少なく，満足のいく結果であった．

しかし，術前斜視角40プリズム以上の場合には，術後眼位が術直後から低矯正になることが多く，術後の戻りも斜視角の小さいものに比べると大きいことが明らかとなった．この理由としては，①斜視角の大きい症例では，推奨されている後転量よりも実施された術量が少なかった．②Wrightも述べているが，外眼筋のまつわり量が影響しており，大量の後転では，1mmあたりの矯正効果が大きいため，過矯正と同様に低矯正も起こりやすい．③筋間膜の剝離，前部テノン嚢の剝離を最小限にしているために，これらの組織の張力が影響した，などが考えられる．

両外直筋後転と前後転術の比較では，両外直筋後転のほうが，lateral incomitanceが起こりにくい，術後の疼痛や炎症が少ない，定量が正確である，筋への侵襲が少ない，長期的な戻りが少ない，などの利点が知られている．

基礎型斜視には，前後転術を，開散過多型あるいは見かけ上の開散過多型では，両外直筋後転術が一般的には，勧められている[2]．見かけ上の開散過多型の中にはプリズムアダプテーションテストによって，近見眼位が増加するものがあり，それらはtenacious proximal fusionとよばれる[3]．今回の我々の症例では，真の開散過多型外斜視は，わずか6例しかみられていない．見かけ上の開散過多型をプリズムアダプテーションテストや，＋3Dを加入して眼位を測定することによって，基礎型と診断したことによる．

また多施設による無作為試験では，眼優位性のある斜視に対しては，両眼外直筋後転術より，前後転術のほうが術後眼位は統計的に有意に良好であったが，両外直筋後転では過矯正がなかったのに対して，前後転術では術後過矯正がみられ，両眼視機能が不良となる可能性が高かった，との報告もある[4]．

両眼手術に対する本人および家族の心理的抵抗が予測されたが，多くの場合，家族や本人はどちらの眼も偏位することに気づいており，両眼手術への抵抗は少ない．さらに，手術終了時の眼軟膏を点眼にしたこと，眼帯をしないことによって，手術室での覚醒時に患者が安心し落ち着きが早期にみられた．

両眼外直筋後転術は，40プリズム以下の間欠性外斜視にとって，早期から眼位の安定を得られ，眼位の予測も良好であると思われた．

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Superior Oblique Palsy with Class III Tendon Anomaly

MIHO SATO, EMI AMANO IWATA, YOSHIKO TAKAI, AKIKO HIKOYA, AND YUKA MARUYAMA KOIDE

• PURPOSE: To describe the clinical findings and surgical results of superior oblique palsy with class III tendon anomaly.

• DESIGN: Observational case series.

• METHODS: One hundred and forty-one cases of congenital and idiopathic superior oblique palsy were operated on by one surgeon (M.S.) between September 1, 1995 and August 31, 2007. The superior oblique tendons were explored in 26 cases. Among these, five cases were found to have the distal end of the tendon inserted into the Tenon capsule. Preoperative eye alignment, visual acuity, stereopsis measured with Titmus stereo acuity tests (Stereo Fly SO-001; Stereo Optical Co, Chicago, Illinois, USA), and magnetic resonance imaging findings were collected from the patients' records. Main outcome measures included preoperative eye position, surgical results, and stereoscopic acuity. Stereopsis and the amount of vertical deviation were compared in cases with class I, II, and IV tendon anomalies.

• RESULTS: A total of eight surgeries were performed on five patients with class III superior oblique tendon anomaly. Three muscles were operated on for each patient. The amount of vertical deviation was not significantly different from other types of tendon anomaly. Patients with class I to III tendon anomalies obtained good stereopsis after strabismus surgery, whereas cases with class IV anomaly achieved only limited stereopsis. The number of surgeries performed was significantly higher in cases with class IV anomaly.

• CONCLUSIONS: Without careful search of the Tenon capsule, the condition can be misdiagnosed as an absent tendon. Strengthening the superior oblique tendon in the Tenon capsule can improve the alignment significantly. (Am J Ophthalmol 2008;146:385–394. © 2008 by Elsevier Inc. All rights reserved.)

CONGENITAL SUPERIOR OBLIQUE PALSY OFTEN IS associated with anatomic abnormalities of the superior oblique tendon,[1] hypoplasia of the superior oblique muscle,[2,3] or poor contractility of the superior oblique muscle.[4] Helveston and associates proposed a classification of congenital superior oblique palsies based on the congenital anomalies of the superior oblique tendon.[1] Eyes classified as class I included those with loose tendon that were raised easily from the sclera, whereas eyes classified as class II had an insertion of the superior oblique muscle in the sclera more nasally than usual. Eyes classified as class III had a thin tendon that inserted in the Tenon capsule, and those classified as class IV lacked a tendon.

The clinical characteristics of eyes with a class IV tendon anomaly, the most severe form of tendon anomaly, have been reported by several authors.[5,6] However, a computerized search of MEDLINE extracted only one report on the clinical characteristics and surgical results on eyes with class III congenital anomaly of the superior oblique tendon. Helveston and associates found only two cases of class III anomaly in the 82 patients they studied.[1] In an article in Japanese, Lo reported two cases among the 100 cases of superior oblique palsy.[7] We reported two cases of class III congenital tendon anomaly at the IX International Orthoptic Congress in 1999.[8] The purpose of this study was to determine the clinical characteristics and surgical results of five cases of class III anomaly of the superior oblique tendon and to compare these findings with the characteristics of other types of anomalies of the superior oblique tendon.

METHODS

ONE HUNDRED AND FORTY-ONE CASES OF CONGENITAL OR idiopathic superior oblique palsy that had undergone surgery by one surgeon (M.S.) between September 1, 1995 and August 31, 2007 were studied. A diagnosis of superior oblique palsy was made by the following clinical findings: 1) hypertropia in the primary position, 2) increase in the hypertropia on contralateral gaze, and 3) positive Bielschowsky head tilt test results. Patients known to have these signs from infancy or early childhood or patients without a clear documentation of the onset were considered to have disease of congenital or idiopathic origin.

Magnetic resonance imaging (MRI) or computed tomography (CT) of the orbit was carried out on 96 patients. The belly of the superior oblique muscle was confirmed to be present in coronal or horizontal MRI sections in 94 cases, and the superior oblique muscle was not detected in either coronal and horizontal images in two cases.

The traction test of the superior oblique tendon was performed during surgery under general anesthesia. All of the superior oblique tendon traction tests were performed

Accepted for publication May 13, 2008.

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0002-9394/08/$34.00
doi:10.1016/j.ajo.2008.05.013

TABLE 1. Profiles of Patients with Class III Superior Oblique Tendon Anomaly

Case No.	Gender	Affected Side	Head Tilt	Age at Presentation (yrs)	Side	VA	Deviation in Primary Position (PD)	SPD in ADD	IFD in ADD	Image of SO	TST Results (before Surgery)
1	M	L	R	3	R	1.2	12 LHT, 16 XT	+3	−3		7/9
					L	1.2		0	0	Attenuated LSO	
2	M	R	L	2	R	0.7	20 RHT, 25 XT	+2	−3		Fly (−)
					L	1.0		0	0	Attenuated RSO	
3	M	L	R	2	R	0.8	8 LHT, 14 XT	0	0		Fly (−)
					L	1.0		+1	−3	Attenuated LSO	
4	F	R	L	11	R	1.0	20 RHT, 10 XT	+3	−2		9/9
					L	1.2		0	0	Attenuated RSO	
5	F	L	no	2	R	1.0	18 LHT	0	0		4/9
					L	1.0		+2	−3	Attenuated LSO	

ADD = adduction; F = female; HT = hypertropia; IFD = infraduction; L = left; LH = left hyperphoria; M = male; PD = prism diopters; R = right; SO = superior oblique muscle; SPD = supraduction; TST = Titmus stereo test; VA = visual acuity; XT = exotropia.

TABLE 2. Intraoperative Findings and Surgical Results of Patients with Class III Superior Oblique Tendon Anomaly

Case No.	Age at Surgery (yrs)	Traction Test of SO Tendon	Surgery	Postoperative Eye Position	TST Results (after Surgery)
1	3	R, 0; L, −1	LIO myectomy	Orthophoria in primary position, small XT in upgaze	
	5	R, 0; L, −1	LSO reposition, LLR recess 5 mm	V pattern XT	9/9
2	2	R, −3; L, 0	RIO myectomy, RSO reposition, RSR recess 2 mm	Orthophoria in primary position, −1 SPD in ADD, OD	Fly (−)
3	2	R, −4; L, 0	LIO myectomy, LSO reposition	8 PD LH	
	5	R, −1; L, 0	RIR recess 2 mm	Orthophoria	9/9
4	11	R, −4; L, 0	RIO myectomy, RSR recess 3 mm	18 PD LHT, 7 XT	
	12		RSR advance to original insertion	5 LHT, −1 SPD in ADD, OD	9/9
5	4	R, 0; L, −1	LIO myectomy, LSO reposition, LSR recess 3 mm	5 RHT, 7 XT, −1 SPD in ADD, OS	9/9

ADD = adduction; L = left; LH = left hyperphoria; HT = hypertropia; IO = inferior oblique muscle; LR = lateral rectus muscle; OD = right eye; OS = left eye; PD = prism diopters; R = right; RSR = right superior rectus muscle; SO = superior oblique muscle; SPD = supraduction; TST = Titmus stereo test; XT = exotropia; yrs = years.

by one surgeon (M.S.) and were graded on a 9-point scale from −4 to 4.[9,10] To do this, the surgeon sat at the head of the supine, anesthetized patient. Two toothed forceps were used to grasp the limbus at the 2- and 8-o'clock positions of the left eye and the 4- and 10-o'clock positions of the right eye. The eye was rotated upward to the superior nasal quadrant by elevating and adducting the eye while the globe was retropulsed. Then the eye was moved nasally and temporally, and this movement allowed the surgeon to feel the tendon as a band as it moved across the globe as it was rocked. The laxity or tightness of the tendon was recorded on a scale of −4 to 4 as: 0, normal; −1 (+1), mild laxity (tightness); −2 (+2), moderate laxity (tightness); −3 (+3), severe laxity (tightness), but the tendon was present and the eye moved past the midline; and −4 (+4), no tendon (limited supraduction above the midline).

When the patients had one of the following findings, we explored the superior oblique tendon in the scleral space through a superior temporal incision: 1) the superior oblique tendon was attenuated significantly on the MRI or CT scans; 2) the traction test of the superior oblique tendon was graded as −3 or −4; 3) cases with residual head tilt after ipsilateral inferior oblique weakening; and 4) the vertical deviation was more than 20 prism diopters (D).

Among the 26 cases, the superior oblique tendon was found to be attached to the sclera in 18 eyes. Fifteen of these were confirmed to have a class I anomaly and three had a class II anomaly. In the other eight eyes, the superior oblique tendon was not attached to the sclera, that is, a class III or IV anomaly. After a careful search for the Tenon capsule during surgery, the superior oblique tendon was found to be inserted into the Tenon capsule in five

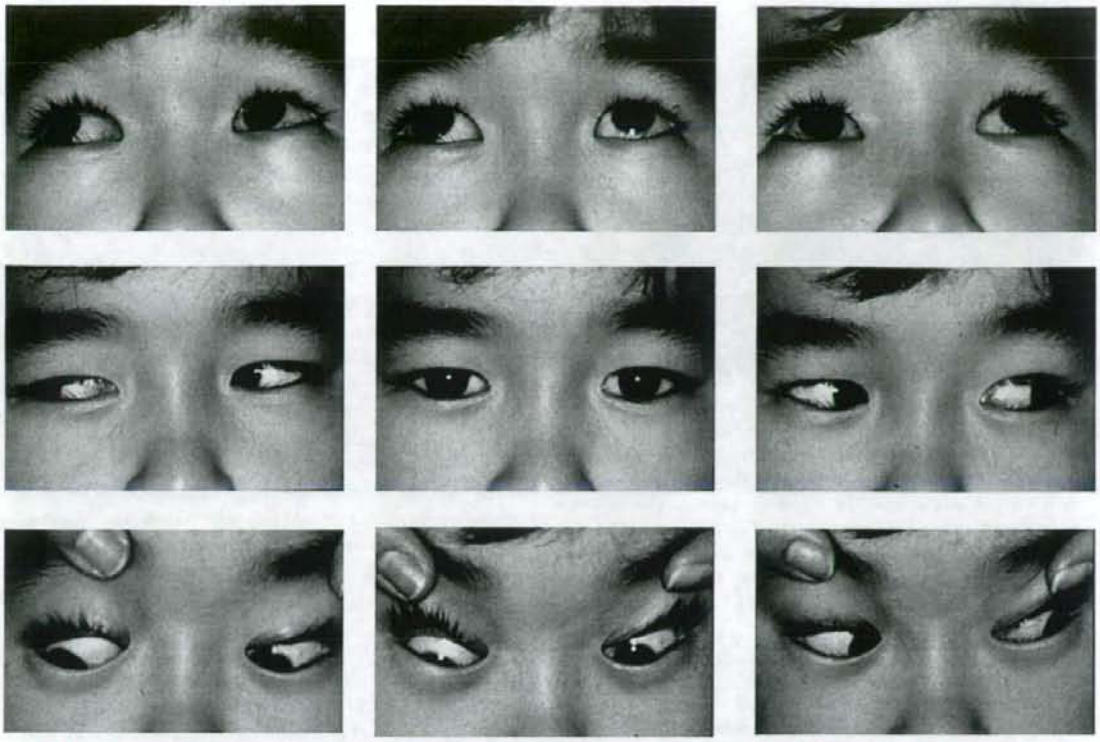

FIGURE 1. Photographs demonstrating the eye positions of a 4-year-old-boy with class III superior oblique tendon anomaly (Case 1). The positions of the eyes in the nine fields of gaze after inferior oblique muscle myectomy show an underaction of infraduction in the adducted position of the left eye.

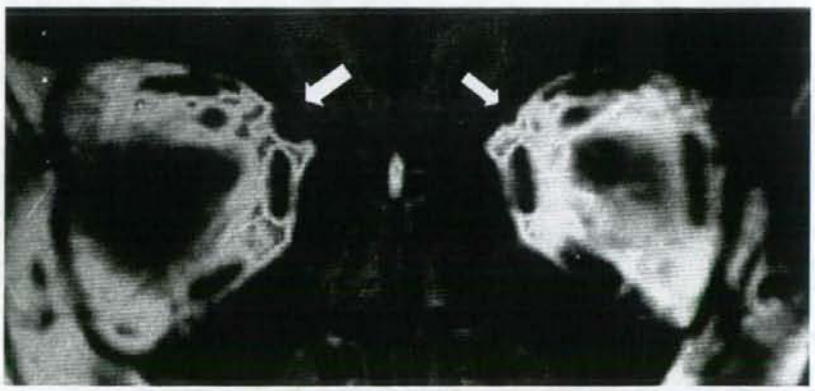

FIGURE 2. Coronal magnetic resonance imaging scan of a 4-year-old boy with class III tendon anomaly (Case 1) showing a marked hypoplasia of the left superior oblique muscle. The larger white arrow points to the right superior oblique tendon and the smaller white arrow points to the left superior oblique tendon.

cases, and these cases were diagnosed as a class III anomaly. The superior oblique tendon was not found in three cases, and these were diagnosed as a class IV anomaly. Two of the class IV cases were diagnosed as an absent superior oblique muscle on MRI, but one of them appeared to have it on MRI.

We analyzed the vertical deviation, postoperative stereo acuity, and the number of surgeries performed among the

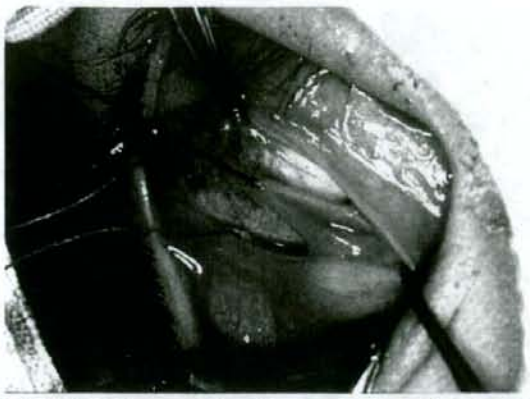

FIGURE 3. Intraoperative photograph obtained during the second surgery performed one year later in Case 1 for inferior oblique muscle myectomy. The patient was 5 years of age. The superior rectus muscle was detached from the sclera, and its insertion site was grasped by a pair of forceps. The superior oblique tendon was identified in the Tenon capsule and was pulled with a black suture (surgeon's view). The superior oblique tendon was dissected from the Tenon capsule and sutured to the sclera. Then, the superior rectus muscle was sutured on to the original site.

four types of tendon anomalies statistically. For statistical purposes, the stereo acuity of a patient who failed the Titmus fly (3000 seconds of arc) was set at 5000 seconds of arc. We performed an analysis of variance and used the Fisher Protected Least Significant Difference (PLSD) as a post hoc test with Stat View software for Windows version 5 (SAS Institute Inc, Cary, North Carolina, USA). *P* values of less than .05 were considered to be statistically significant.

RESULTS

THE PROFILES OF THE FIVE PATIENTS ARE SUMMARIZED IN Table 1, and the surgical results are summarized in Table 2. Eight surgeries were performed on the five patients with a class III tendon anomaly, and three muscles were operated on in each patient.

• CASE 1: A boy with a head tilt to the right underwent a left inferior oblique muscle myectomy at 4 years of age. Forced traction testing of the superior oblique tendon during the surgery revealed a −1 laxity. His head tilt was reduced, but some degree of head tilt was still present after the surgery (Figure 1). A second surgery was performed when he was 5 years of age. A preoperative MRI scan demonstrated a marked hypoplasia of the left superior oblique muscle (Figure 2). A forced traction test of the superior oblique tendon during the surgery revealed a −1 laxity. The superior oblique tendon was found at the nasal edge of the superior rectus muscle, and it was traced to its insertion into the Tenon capsule (Figure 3). The tendon was advanced and sutured to the sclera at the temporal border of the superior rectus muscle. The superior rectus muscle was reattached at its original position. After surgery, a small V-pattern exotropia was detected, but otherwise his eyes were well aligned and the abnormal head posture was no longer present (Figure 4). His stereo acuity was 40 seconds of arc.

• CASE 2: A 2-year-old boy with a severe head tilt to the left (Figure 5) had a marked hypoplasia of the right superior oblique muscle on MRI (Figure 6). The traction tests of the right superior oblique tendon demonstrated a marked laxity (−3), but the tendon was believed to exist. A myectomy of the right inferior oblique muscle was performed, and during the surgery, the superior oblique tendon was identified under the superior rectus muscle as a thin and loose structure that inserted into the Tenon capsule. When traction was placed on the tendon, an indentation was seen on the external surface of the upper lid, suggesting that the tendon not only had migrated into the Tenon capsule, but also was firmly attached to the levator aponeurosis.

The superior oblique tendon was dissected and sutured to the sclera 4 mm temporal to the temporal border of the superior rectus muscle and 14 mm posterior to the limbus. The superior rectus muscle was recessed 2 mm from its original insertion. Interestingly, the shape of the right upper lid crease changed after the surgery (Figure 7). His left eye was diagnosed as having anisometropic amblyopia with a visual acuity (VA) of 0.7. The patient was treated by optical correction and occlusion of the left eye. The final VA was 1.0 in the left eye at 5 years of age, but stereopsis was not present with the Titmus stereo acuity test because of suppression of the left eye.

• CASE 3: Patient 3 had a −4 laxity of the superior oblique tendon, but the tendon was found in the Tenon capsule (Figure 8) and was repositioned. Myectomy was performed on the left inferior oblique muscle, but he still had a residual head tilt and left hypertropia. Three years later, the contralateral inferior rectus muscle was recessed by 2 mm, and a postoperative MRI scan showed a marked hypoplasia of the superior oblique muscle.

• CASE 4: Patient 4 underwent surgery, and forced traction test of the superior oblique tendon during the surgery revealed −4 laxity. The right superior oblique tendon was found in the Tenon capsule. The tendon was too thin to match the tightness of the fellow eye. Therefore, the superior rectus muscle was recessed for 3 mm, and myectomy was performed on the inferior oblique muscle. After the surgery, the patient had a left hypertropia and the head tilt was reversed. A second surgery was performed to advance the recessed superior rectus muscle one year later.

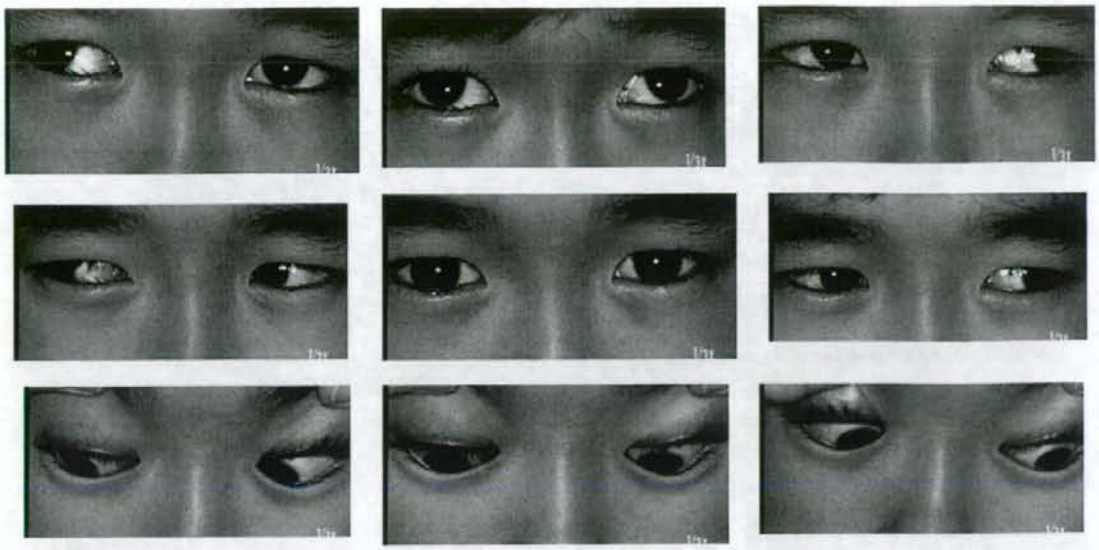

FIGURE 4. Photographs demonstrating the eye positions of a 5-year-old boy with class III tendon anomaly (Case 1) after repositioning of the superior oblique tendon found in the Tenon capsule. Infraduction in the adducted position is improved in the left eye without Brown syndrome. Mild V-pattern exotropia is present.

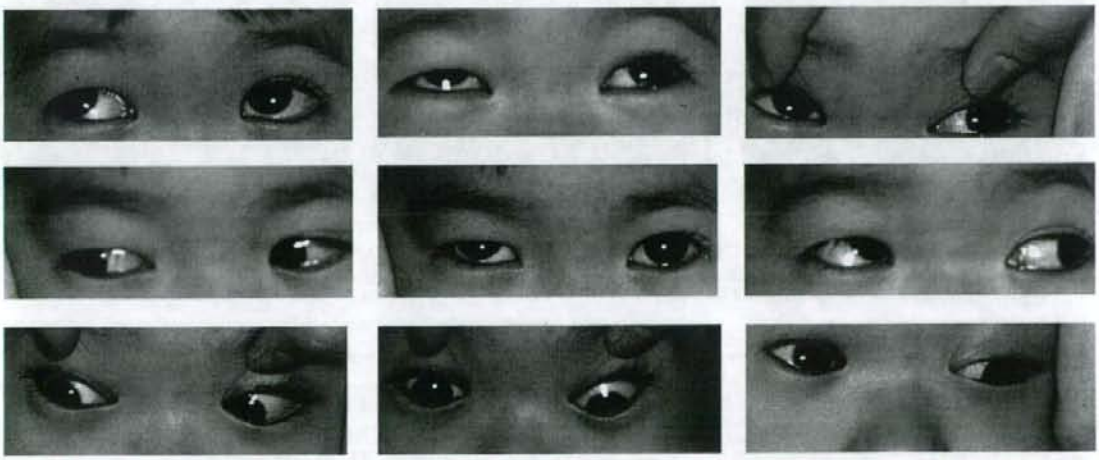

FIGURE 5. Photographs demonstrating the preoperative eye positions in the nine fields of gaze of a 2-year-old boy with class III superior oblique tendon anomaly (Case 2). Underaction of infraduction in the adducted position (−3) and overaction of supraduction in the adducted position (+2) of the right eye can be seen.

During the second surgery, a traction test of the superior oblique tendon was graded as −4, and the superior rectus muscle was found to be attached to the sclera 6 mm posterior from the original insertion rather than at 3 mm.

• CASE 5: Patient 5 did not have a head tilt and the left eye fused well in the primary position. Her vertical deviation increased to 18 prism D after prolonged occlusion of the left eye (Figure 9). However, the patient had a large hypertropia when the head was tilted to the left, which was a cosmetic problem. Her CT scan showed a marked hypoplasia of the left superior oblique muscle, and the left trochlea was found to be located more posterior than on the right side (Figure 10). Forced traction testing of the superior oblique tendon revealed only a mild looseness (−1). Myectomy was performed on the left inferior oblique muscle. However, a thin superior oblique tendon was found in the Tenon capsule not attached to

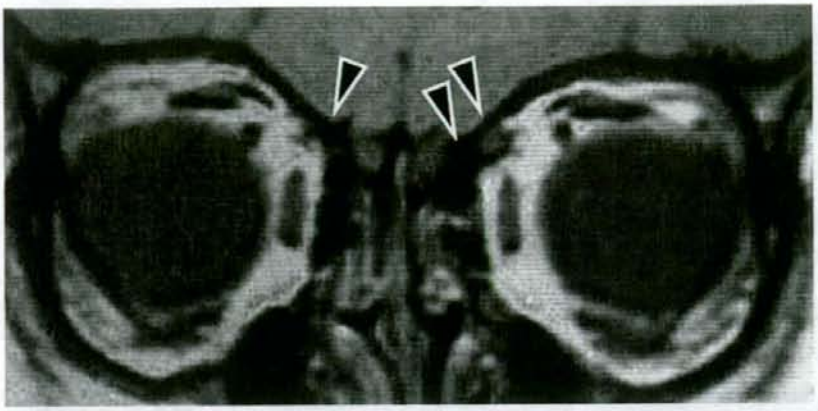

FIGURE 6. Coronal magnetic resonance imaging scan from a 2-year-old boy with class III superior oblique tendon anomaly (Case 2). The black triangles indicate superior oblique tendons. The right superior oblique tendon is markedly hypoplastic.

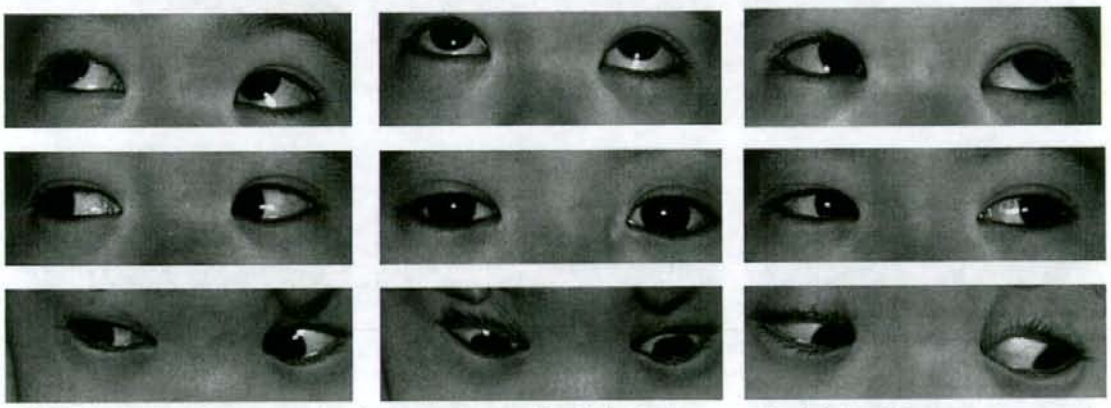

FIGURE 7. Photographs demonstrating the eye positions in Case 2 obtained one year after inferior oblique myectomy, superior oblique tendon repositioning, and 2-mm superior rectus muscle recession of the right eye performed when he was 2 years of age. The superior oblique tendon was attached firmly to the levator aponeurosis. Note that the single lid crease of the right eye changed to a double crease after surgery.

the sclera (Figure 11). The tendon was detached from the Tenon capsule and sutured to the sclera 6 mm temporal to the temporal border of the superior rectus muscle and 12 mm posterior to the limbus. The superior rectus muscle was sutured 3 mm posterior to the original insertion. After surgery, she showed mild supraduction limitation in the adduction position, but it was not a problem cosmetically.

The degree of vertical deviation, number of surgeries performed, and postoperative stereopsis of the 26 cases classified into the four types of tendon anomalies confirmed by exploration of the superior oblique tendons are shown in Table 3. The average vertical deviation was largest in class IV, but it was not statistically significant. The stereo acuity measured with the Titmus stereo test of class III anomaly was significantly better than that of the class IV anomaly ($P < .05$), but it was indistinguishable with class I and II anomalies. The number of surgeries was significantly higher in the class IV anomaly than in the class I anomaly ($P < .05$).

In summary, two cases obtained satisfactory results with one operation (Cases 2 and 5), but three cases required additional surgery. A total of eight operations were performed on these five children: two for undercorrection (Cases 1 and 3) and one for overcorrection (Case 4). All but Case 5 had an abnormal head tilt contralateral to the affected eye. All but one case (Case 2) achieved 40 seconds of arc on the Titmus stereo acuity test after surgery. All cases showed significantly attenuated superior oblique muscle bellies on CT or MRI, and horizontal images showed superior oblique tendons and trochlears. The evaluation of the traction testing varied from −1 to −4.

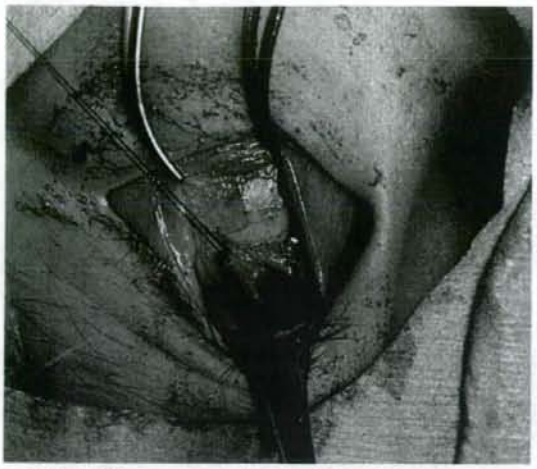

FIGURE 8. Intraoperative photograph from Case 3, a 2-year-old boy with class III superior oblique tendon anomaly. The superior rectus muscle was detached and the insertion of the superior rectus muscle was grasped by two pairs of fixation forceps. The superior oblique tendon was identified and pulled up by a black suture. The tendon was connected to the deep orbit and was not attached to the sclera.

DISCUSSION

AMONG 141 CASES OF CONGENITAL OR IDIOPATHIC SUPERIOR oblique palsy, we identified five cases of class III superior oblique tendon anomaly that had an insertion of the tendon into the Tenon capsule. Because we did not explore the superior oblique tendon in all cases, we cannot report the real incidence of class III tendon anomaly. Despite this, the incidence in our series is comparable to that of Lo, who explored the superior oblique tendons on 100 superior oblique palsy cases and reported that two of them had class III anomaly.[7] The incidence of class III tendon anomaly among the patients who had at least one of the following findings was five (19.2%) of 26: vertical deviation more than 20 prism D, traction test of the superior oblique tendon under general anesthesia of −3 or −4, attenuated superior oblique muscle in coronal images, and the patient with a residual head tilt after the first surgery.

Wallace and von Noorden reported that the clinical characteristics of eyes with a congenital absence of the superior oblique tendon were: 1) large horizontal deviation, 2) amblyopia, 3) poor binocularity, 4) spread of comitance, and 5) pseudooveraction of the contralateral superior oblique muscle.[5] Chan and Demer reviewed the clinical findings of six patients whose superior oblique muscle could not be detected by imaging methods.[6] They reported that the findings in these cases overlapped the clinical findings in cases with a demonstrable superior oblique muscle on neuroimaging scans. None of their patients was amblyopic and two had good stereopsis.

The characteristics of class IV tendon anomaly in our cases are summarized in Table 4. The amount of vertical deviation was larger than that of class III cases, but the difference was not statistically significant. None of the patients had measurable stereopsis after surgery.

When both the coronal and horizontal images did not show a superior oblique tendon, this indicated a class IV anomaly. Although imaging studies may indicate an absence of the superior oblique muscle and tendon (class IV anomaly), the skeletal muscle portion may be attenuated severely, and a superior oblique tendon in fact may be present. However, if the superior oblique tendon is found in the images, it does not necessary indicate that the superior oblique tendon is attached to the sclera. Therefore, these tendons need to be explored surgically to make a definitive diagnosis.

There are some clues to differentiate class III from class VI tendon anomalies. Stereopsis seems to be more likely to be achieved for class III tendon anomalies. In our series, two of our class III patients had more than 100 seconds of arc of stereo acuity at their initial evaluations. Four of five cases obtained 40 seconds of arc stereopsis after surgery. Only the patient who had anisometropic amblyopia with suppression did not pass Titmus fly (3000 seconds of arc). Vertical deviations of more than 30 prism D can be an indicator of the class IV tendon anomaly.

Because the superior oblique tendon in class III anomaly does not attach to the globe, the result of the traction test is expected to be −3 or −4 laxity. But in our five patients, the traction test of Cases 1 and 4 showed only a mild laxity. Because of the subjective nature of this test, minor differences between examiners are expected,[11] and the consistency of the test has not been evaluated. However, all of the tendons were evaluated by one surgeon (M.S.) and the test between the first and second surgery were consistent. Therefore, variations in the traction test should be the result of other factors. One possible reason is that although the globe was retropulsed and rotated upward during the traction test, the insertion of the superior oblique tendon in the Tenon capsule also moved backward with the globe. This stretched the tendon, which would cause some tension during the traction test.

The mechanisms that led to the clinical differences between class III and class IV tendon anomalies also are unclear. We suspected that the tendon inserted into the Tenon capsule still has some torsional effect on the globe by transmitting its contractility to the globe through the connective tissue surrounding the tendon. This may result in less vertical deviation and less disruption of stereopsis.

One or more of the following surgical procedures generally is recommended for treating superior oblique palsy: inferior oblique muscle weakening, inferior oblique muscle anterior transposition, superior oblique tendon strengthening, superior rectus muscle recession, contralateral inferior rectus muscle