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Long-Term Outcome of Medial Rectus Recession and Pulley Posterior Fixation in Esotropia With High AC/A Ratio

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Abstract

Purpose: Medial rectus (MR) recession with pulley posterior fixation (PF) can be used to treat esotropia (ET) with a high accommodative convergence to accommodation (AC/A) ratio as effectively in the short term as MR recession with scleral PF. This study provides a novel examination of the long-term results of MR recession with pulley PF (PPF).

Methods: In 21 children we performed bilateral MR recession and pulley PF for ET greater at near than distance (high AC/A). Mean follow-up was 3.5 ± 2.5 (standard deviation [SD]) years.

Results: Mean age at presentation was 2.7 ± 1.8 and at surgery 4.3 ± 1.6 years. Fourteen (67%) children had amblyopia. Distance and near pre-operative ET averaged $19.6\Delta \pm 10.5\Delta$ and $36.9\Delta \pm 18.9\Delta$, respectively. Mean near-distance (N-D) disparity was $16.4\Delta \pm 12.3\Delta$. The MR recession averaged 4.4 ± 0.9 mm. Early mean postoperative ET was $1.3 \pm 3.3\Delta$ at distance and $2.8\Delta \pm 5.2\Delta$ at near. Mean late postoperative ET was $0.1\Delta \pm 5.8\Delta$ and $1.0\Delta \pm 6.2\Delta$ at distance and near, respectively. At the final postoperative examination, mean N-D disparity was reduced to $0.9\Delta \pm 3.6\Delta$.

Discussion: MR recession with PPF has a high long-term effectiveness, even in patients with amblyopia and autism. Since no posterior scleral suturing is required, it minimizes the perforation risk associated with scleral PF.

Conclusion: MR recession with PPF is a safe and highly effective long-term treatment for ET with high AC/A ratio. Long-term results may surpass those of alternate procedures.

Keywords

Esotropia; Pulley; Strabismus

INTRODUCTION

The standard treatment for children with refractive accommodative esotropia (ET) is full correction of hyperopia, with bifocal lenses if needed to control the near ET that typically

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exceeds distance deviation. The primary benefits of bifocals are rapid restoration of binocularity at near, and avoidance of the expense and risks of surgery (Leuder & Norman, 2006). Sometimes spectacles do not fully correct the ET, which is then considered partially accommodative. Even after successful correction of ET with spectacles, control may deteriorate, requiring surgery (Ludwig, 2003). ET associated with excessive accommodative convergence is considered to exhibit a high accommodative convergence-to-accommodation ratio (AC/A ratio) (von Noorden, 1996). The term “high AC/A ratio” is inconsistently defined and quantitatively problematic, as has been discussed in detail in a recent textbook chapter (Demer, 2011). Depending upon the definition, the quantitatively normal AC/A ratio is either zero, or equal to the interpupillary distance in centimeters (Demer, 2011). As commonly employed in clinical strabismus practice, the term “high AC/A” is a quasi-quantitative concept, indicating merely that the heterophoria during accommodation (as during near target viewing) is more converged than when accommodation is relaxed (as during viewing of a far target). Actual numerical values of the AC/A ratio are virtually never published in clinical reports. The present report uses the term “high AC/A” in the common clinical sense, without computing it numerically.

The traditional surgical procedures for ET with high AC/A ratio include augmentation of the amount of medial rectus (MR) recession, slanted MR recession, and MR recession with scleral posterior fixation (PF) (*Fadenoperation*). Gharabaghi and Zanjani compared these three options, and found that combined MR recession with PF had the best outcome, yet recommended slanted recession as being less invasive than the MR recession with PF (Gharabaghi & Zanjani, 2006). Kushner preferred augmented MR recession that targeted the measured ET angle during near viewing (Kushner, 2001).

Notwithstanding Gharabaghi and Zanjani’s seemingly paradoxical recommendation of what they report to be a suboptimally effective procedure (Gharabaghi & Zanjani, 2006), appropriate surgery for ET with high AC/A ratio remains controversial. Scleral PF consists of suturing the muscle belly to the underlying sclera posterior to the muscle insertion, and thus near the globe equator. The operation was formerly thought to act by inducing loss of muscle tangency with the globe during contraction (Scott, 1977), or by shortening the arc of contact (Scott, 1977), or by slackening the muscle (Kushner, 1983), or making some of the muscle fibers inactive (Kushner, 1983). However, scleral PF does not progressively reduce peak saccadic velocity in the medial rectus muscle’s field of action as would be expected if the operation weakened the muscle as hypothesized by all of the foregoing mechanisms that suppose muscle weakening (Kushner, 1983).

A restrictive mechanical explanation for the effectiveness of PF has since emerged. Advanced magnetic resonance imaging pioneered by Miller led to the modern concept of pulleys (Miller, 1989), which are demonstrated to be composed of dense collagen, elastin and smooth muscle (Demer, 2002, 2004; Demer et al., 1995; Kono et al., 2002). While the global layer of each rectus muscle passes through its pulley to become contiguous with the tendon to insert on the globe, the orbital layer inserts on the pulley (Demer et al., 2000; Lim et al., 2007). The extraocular muscle segment between the scleral insertion and the pulley defines the direction of force applied to the globe, while the insertion of each rectus muscle orbital layer on its pulley appears to be the main driving force translating that pulley posteriorly during contraction (Demer, 2004, 2006). Scleral PF acts by constraining this posterior movement of the pulley against elastic tissues that are anteriorly-anchored to the bony orbit, producing a mechanical restriction that limits duction in the muscle’s field of action (Clark et al., 1999). Based on this understanding, Clark et al. proposed that surgical manipulations of the pulleys for the treatment of strabismus may not require suturing to the sclera (Clark et al., 2004b). In pulley PF (PPF) surgery, Clark et al. suggested that when the eye is abducted by the tension of a muscle hook placed under the MR’s scleral insertion, the

MR belly is telescoped anteriorly through its pulley sleeve. After suturing the MR to its pulley in this position, the MR can no longer telescope posteriorly through the pulley. When the globe is rotated into primary position, the pulley sleeve is displaced posteriorly along with the muscle belly because it is sutured to the MR. The connective tissue that suspends the pulley from the anterior bony orbit resists elongation, creating a passive elastic force opposing MR tension in primary gaze that increases further when the eye is adducted (Clark et al., 2004b).

Clark et al. have reported the short-term outcome of MR recession with PPF to be similar to that of traditional scleral PF (Clark et al., 2004a). Another recent report shows a high short-term success for PPF in high AC/A ratio ET (Kowal L and Mitchell L, paper presentation at International Strabismological Association, Istanbul, 2010). In addition to confirming the findings of previous anatomic and MRI studies on location of EOMs pulleys, recent work points out surgically evident individual variations in pulley anatomy to which a surgeon may sometimes adapt intra-operatively (Thouvenin D, Lesage C, Norbert OO, Chapotot E, paper presentation at International Strabismological Association, Istanbul, 2010).

Although short-term outcomes of PPF have been encouraging, long-term data have not been reported. The current study examined long-term results of PPF.

MATERIALS AND METHODS

One surgeon (JLD) performed PPF with or without MR recession in 21 consecutive patients who had ET associated with increased AC/A ratio between 2001 and 2010. The same surgeon performed all alignment measurements. Records of these patients were reviewed retrospectively under a protocol approved by the local Institutional Review Board and conforming to the Declaration of Helsinki. There were no exclusion criteria for operated patients who had the qualifying diagnosis. Patients with amblyopia, autism, and neurological disease were thus included in the analysis. However, follow-up was truncated to the 6-year period of normal binocular vision in Patient 6, who developed a late sensory exotropia due to visual loss resulting from laser treatment of a macular cavernous hemangioma in one eye.

The following information was extracted from the records: age at the time of presentation and surgery, gender, visual acuity, stereopsis when it could be determined, presence of amblyopia, strabismic deviations preoperatively and postoperatively, follow-up period, complications, and cycloplegic refractions. High AC/A accommodative ET was diagnosed in the presence of hyperopia with spherical equivalent exceeding +2.00 D if the angle of ET measured with full cycloplegic correction at 30 cm was 5Δ or more than that measured at 4 m. Cycloplegia was achieved by applying cyclopentolate 1% drops three times at 5-minute intervals for dark irides, and once for blue irides. Atropine 1% drops were employed for 3 days in two where cyclopentolate did not achieve stable cycloplegia. Refraction was by streak retinoscopy. Alignment was measured by prism and cover testing at 4 m and 30 cm.

If a visual acuity deficit of two or more lines was found in either eye after full correction for refractive error in the absence of structural abnormality in the visual pathway, amblyopia was diagnosed. In preverbal patients, strong preferential fixation was alternatively taken as evidence of amblyopia. Treatment for amblyopia was by patching the dominant eye 2 or more hours daily. Spectacles were prescribed with the full hyperopic correction if a spherical equivalent hyperopia of at least +2.00 D was present. When full hyperopic correction eliminated ET at distance but ET persisted at near, a bifocal of minimally sufficient power was added to correct the near deviation. If ET persisted at distance with full hyperopic correction, strabismus surgery was performed. This means that surgery was performed only if ET could not be corrected by bifocals. Parks's tables were used to dose

the medial rectus recession (Parks, 1991). Prism adaptation testing was not performed. Final measurements were made immediately prior to surgery, and a target angle determined by the distance deviation measured with full hyperopic spectacle correction, if spherical equivalent hyperopia of at least +2.00 D was present. If postoperatively the distance ET was eliminated but near ET existed, a bifocal was prescribed if this eliminated the near ET. Hyperopic spectacle power was conservatively reduced in long-term follow-up as tolerated, as long as orthotropia was maintained.

Forced duction testing was performed under general anesthesia immediately prior to surgery. The conjunctiva was opened at the limbus adjacent the MR insertion. The MR was exposed by conservative blunt dissection, disinserted at the sclera, and reattached to the sclera at the distance of recession using two 6-0 absorbable sutures placed in the tendon margins. After the recession was completed, the new surgical insertion was engaged with a hook to abduct the eye. Along both the superior and inferior MR margins, small hooks were then advanced along the orbital surface posteriorly to engage the corresponding anterior parts of the pulley. Non-absorbable 5-0 polyester sutures were then passed through the anterior pulley tissue, and tied through the adjacent 20% of the MR width so that the pulley was fixed to both the superior and inferior margins of the muscle. The conjunctiva was closed to the limbus using 9-0 absorbable sutures. Immediate forced duction testing was then performed in most cases, indicating new restriction to full adduction of each operated eye.

Each patient was examined about 2 hours postoperatively, and again within the first postoperative week. Subsequent examinations were at 6 weeks, 3 months, and later at appropriate intervals up to annually. The early postoperative deviations reported were obtained within the first week after surgery; the late postoperative deviations were obtained at the most recent visit following MR recession and pulley PF surgery, but before any subsequent surgery. The near-distance (N-D) disparity was defined to be the difference between ET measured at near minus ET measured at distance. Stereopsis was taken as the most recent postoperative measurement using the Titmus test, with refractive correction if required. Hyperopic spectacle power was reduced postoperatively as tolerated for maintenance of alignment. The two-tailed, paired Student's t-test was used for assessing significance.

RESULTS

A total of 12 females and 9 males were studied, with mean age at presentation of 2.7 ± 1.8 (standard deviation, SD) years. Mean age at surgery was 4.3 ± 1.6 years (Table 1). Fourteen (67%) patients had amblyopia at initial evaluation. Pre-operative ET averaged $19.6 \pm 10.5\Delta$ for distance and $36.9 \pm 18.9\Delta$ at near, with mean N-D disparity $16.4 \pm 12.3\Delta$. Preoperatively, 17 (85%) required spectacles with average spherical equivalent $+4.10 \pm 2.46$ D for the right eye, and $+4.48 \pm 2.38$ D for the left eye, including seven who unsuccessfully wore bifocals. Seven (33%) patients had spherical equivalent hyperopia in one or both eyes exceeding +5.00 D.

The mean MR recession performed was 4.4 ± 0.9 mm (Table 1). Early mean postoperative ET was $1.3 \pm 3.3\Delta$ at distance and $2.8 \pm 5.2\Delta$ at near. The mean early N-D disparity was $1.5 \pm 4.7\Delta$. After a follow-up averaging 3.5 ± 1.5 years (range 0.25 – 8 years), late postoperative ET was $0.1 \pm 5.8\Delta$ at distance and $1.0 \pm 6.2\Delta$ at near (Figure 1). This reduced the mean N-D disparity to $0.9 \pm 3.6\Delta$. These results are illustrated in Figure 1.

The N-D disparity remained stable in the long term following PPF. The mean early and late postoperative N-D disparity was not significantly different ($P = 0.631$). Postoperatively 15

(71%) continued wearing spectacles, mainly for significant hyperopia, astigmatism, and/or anisometropia, but ultimately none required bifocals. Subjects 8 and 16 both had autism, but responded as well in the long term to MR recession with pulley PF as the other children. Patient 3 had a significant undercorrection resulting in ET with full hyperopic correction of 14Δ at distance and 16Δ at near when evaluated 2 years after MR recession and pulley PF. Patient 3 subsequently achieved satisfactory alignment following bilateral lateral rectus resection.

Since mean age at presentation was less than 3 years, the patients were significantly esotropic, and most had required treatment for amblyopia, we did not consistently evaluate stereopsis pre-operatively. Postoperatively, stereopsis was evaluated in 18 patients using the Titmus test (Table 1). Consistent with early age of onset of ET, eight (44%) patients had no demonstrable stereopsis, two (11%) had only gross stereopsis of 3,000 arcsec, one (6%) had 600 arcsec, and three (17%) had 400 arcsec. Only four (19%) patients had postoperative stereopsis of 50 arcsec or better.

Complications of PPF were rare and mild. There were no overcorrections exceeding 8Δ. Patient 3 developed a late undercorrection resulting in 14Δ distance ET and 16Δ near ET that was treated by bilateral lateral rectus resection 2 years later. Patient 1 developed a pyogenic granuloma 1 year after surgery that was incited by an extruded 5-0 PPF suture. The authors are not aware of any other reports of PPF suture extrusion. Following removal of this suture, the granuloma resolved, and the patient remained satisfactorily aligned at near and distance through 2.5 years follow-up.

DISCUSSION

This study shows that MR recession combined with PPF is effective in the long term for ET with a high AC/A ratio. The operation reduced mean ET to 0.1Δ at distance, and 1.0Δ at near, with a corresponding late mean N-D disparity of only 0.9Δ. The study by Clark et al. (2004a) showed that MR with PPF was as effective as MR with the traditional scleral PF in the short term. The present study confirms and extends these findings to a substantially longer follow-up period.

Clark et al. were originally concerned about the extent to which the pulley suspensory tissues would endure the stress of MR PPF in the long term without diminishing effectiveness of the operation (Clark et al., 2004a). However, the current study indicates no reduction in effectiveness over a mean of more than 3.5 years, and in individual cases up to 8 years. In the present study, 43% of the patients were amblyopic, and two had autism. Nevertheless, the present success rate in motor alignment compares favorably with both Kushner's report (Kushner, 2001) that had 15-year follow-up and Khalifa's study (Khalifa, 2011) that excluded patients with amblyopia. Efficacy despite broad inclusion criteria in the present study support the benefit of MR recession with PPF in a heterogeneous group of real-world cases.

Using MR recession augmented to target the near ET treating high AC/A ratio, six of Kushner's cases required MR recessions exceeding 10.5 mm from the limbus (11 mm in two patients, 11.5 in three, and 12 mm in one) (Kushner, 2001). The alternative technique incorporating PPF would have required less MR recession, theoretically reducing the risk of scleral perforation. Clark et al. (1999) showed that scleral PF works, not by alteration of the MR's lever arm or arc of contact, but by hindering the normal physiologic posterior shift of the pulley during MR contraction. Clark et al. further proposed that aggressive posterior dissection required to place scleral PF sutures far posteriorly may paradoxically diminish the effectiveness of the operation by lysing the connective tissues that produce the required

mechanical restriction to adduction (Clark et al., 1999). This might explain the less satisfactory results with this procedure that Kushner reported when MR recession with scleral PF was compared with the augmented MR recession technique (Kushner, 2001).

Of course, extremely posterior placement of scleral PF sutures also risks perforation of the visually critical posterior retina. PPF avoids both aggressive connective tissue dissection, and scleral suturing. The MR recession and PPF eliminated the need for bifocals in two patients in this series. However, these patients continued to require single vision spectacle correction of hyperopia. The requirement for spectacle wear was not significantly changed in the current study group, whose mean spherical equivalent hyperopia exceeded +3.00 D. Before surgery, 17 (85%) subjects required spectacles, and 15 (71%) required spectacles after surgery. This is similar to the outcome in Kushner's study (Kushner, 2001), in which all but one subject who had hyperopia exceeding +2.50 D continued to require hyperopic spectacle correction to control postoperative ET. While MR recession with PPF may not eliminate the requirement for bifocals, neither this operation nor augmented MR recession eliminates the requirement for hyperopic spectacles if hyperopia exceeds +2.50 D.

The excellent results in the present study did not depend upon stereopsis. Even after achieving excellent postoperative alignment, high grade stereopsis of 50 arcsec or better was achieved in only 4 of 18 (19%) of subjects evaluated, and measurable stereopsis was achieved in only 10 of 18 (56%). The majority of patients had also required treatment for amblyopia.

Bilateral MR scleral PF has been used for treatment of ET manifest only at near, resulting in good motor alignment, decreased necessity for bifocal wear, and improved binocular function (Millicent et al., 1997). Complications have been problematic, however. Jorge et al. showed that even in well-trained hands, scleral PF has a relatively high risk of intraocular complications, most commonly in the form of scars in the region of muscle anchorage (Alio & Faci, 1984). The risk of scleral perforation or deep suture passage in the scleral PF site makes surgeons justifiably apprehensive. The present study indicates that this risk can be avoided entirely by PPF, which does not require any posterior scleral sutures. The present study indicates that PPF is also highly effective in the long term.

Strengths of this study include operation and follow-up by a single surgeon, uniformity of the surgical indication of ET with high AC/A, diversity of other patient characteristics, and the longest follow-up period reported to date for this procedure. However, the study was limited to younger children where ET with high AC/A is prevalent, and results may not be applicable to adults, who are known to undergo age-related attenuation of the connective tissues suspending the rectus pulleys (Kono et al., 2002).

PPF has long-term effectiveness in the treatment of ET associated with high AC/A ratio, and might be superior to alternative surgical treatments. Demonstration of actual superiority would require a carefully designed, direct comparison, by a multicenter prospective study.

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REFERENCES

- Alio JL, Faci A. Fundus changes following faden operation. *Arch Ophthalmol*. 1984; 102:211–213. [PubMed: 6365050]

- Clark RA, Isenberg SJ, Rosenbaum SJ, Demer JL. Posterior fixation sutures: a revised mechanical explanation for the fadenoperation based on rectus extraocular muscle pulleys. *Am J Ophthalmol*. 1999; 128:702–714. [PubMed: 10612506]
- Clark RA, Ariyasu R, Demer JL. Medial rectus pulley posterior fixation is as effective as scleral posterior fixation for acquired esotropia with a high AC/A ratio. *Am J Ophthalmol*. 2004a; 137:1026–1033. [PubMed: 15183786]
- Clark RA, Ariyasu R, Demer JL. Medial rectus pulley posterior fixation: a novel technique to augment recession. *J AAPOS*. 2004b; 8:451–456. [PubMed: 15492738]
- Demer JL, Miller JM, Poukens V, Vinters HV, Glasgow BJ. Evidence for fibromuscular pulleys of the recti extraocular muscles. *Invest Ophthalmol Vis Sci*. 1995; 36:1125–1136. [PubMed: 7730022]
- Demer JL, Oh SY, Poukens V. Evidence for active control of rectus extraocular muscle pulleys. *Invest Ophthalmol Vis Sci*. 2000; 41:1280–1290.
- Demer JL. The orbital pulley system: a revolution in concepts of orbital anatomy. *Ann NY Acad Sci*. 2002; 956:17–32. [PubMed: 11960790]
- Demer JL. Pivotal role of orbital connective tissues in binocular alignment and strabismus: the Friedenwald lecture. *Invest Ophthalmol Vis Sci*. 2004; 45:729–738. [PubMed: 14985282]
- Demer JL. Current concepts of mechanical and neural factors in ocular motility. *Cur Opin Neurol*. 2006; 19:4–13.
- Demer JL. Mechanics of the orbita. *Dev Ophthalmol*. 2007; 40:132–157. [PubMed: 17314483]
- Demer, JL. Vergences. In: Jaeger, EA.; Tasman, PR., editors. *Duane's Ophthalmology*. 2nd. Lippincott Williams and Wilkins; Philadelphia, PA: 2011.
- Gharabaghi D, Zanjani LK. Comparison of results of medial rectus muscle recession using augmentation, faden procedure, and slanted recession in the treatment of high accommodative convergence/accommodation ratio esotropia. *J Ped Ophthalmol Strab*. 2006; 43:91–94.
- Khalifa YM. Augmented medial rectus recession, medial rectus recession plus Faden, and slanted medial rectus recession for convergence excess esotropia. *Eur J Ophthalmol*. 2011; 21:119–124. [PubMed: 20658460]
- Kono R, Poukens V, Demer JL. Quantitative analysis of the structure of the human extraocular muscle pulley system. *Invest Ophthalmol Vis Sci*. 2002; 43:2923–2932. [PubMed: 12202511]
- Kushner BJ. Evaluation of the posterior fixation plus recession operation with saccadic velocities. *J Ped Ophthalmol Strab*. 1983; 20:202–209.
- Kushner BJ. Fifteen-year outcome of surgery for the near angle in patients with accommodative esotropia and a high accommodative convergence to accommodation ratio. *Arch Ophthalmol*. 2001; 119:1150–1153. [PubMed: 11483081]
- Leuder GT, Norman AA. Strabismus surgery for elimination of bifocals in accommodative esotropia. *Am J Ophthalmol*. 2006; 142:632–635. [PubMed: 17011856]
- Lim KH, Poukens V, Demer JL. Fascicular specialization in human and monkey rectus muscles: evidence for anatomic independence of global and orbital layers. *Invest Ophthalmol Vis Sci*. 2007; 48:3089–3097. [PubMed: 17591878]
- Ludwig IH. Long-term study of accommodative esotropia. *Trans Am Ophthalmol So*. 2003; 101:155–161.
- Miller JM. Functional anatomy of normal human rectus muscles. *Vision Res*. 1989; 29:223–240. [PubMed: 2800349]
- Millicent M, Peterseim W, Buckley EG. Medial rectus fadenoperation for esotropia only at near fixation. *J AAPOS*. 1997; 1:129–133. [PubMed: 10532772]
- Parks, MM. Concomitant esodeviations. In: Tasman, W.; Jaeger, EA., editors. *Duane's Foundations of Clinical Ophthalmology*. Lippincott; Philadelphia, PA: 1991. p. 1-21.
- Scott AB. The faden operation: mechanical effects. *Am Orthoptic J*. 1977; 27:44–47. [PubMed: 911397]
- von Noorden, GK. *Binocular Vision and Ocular Motility: Theory and Management of Strabismus*. Mosby; St. Louis, MO: 1996.

FIGURE 1. Esotropia at distance and near in 21 patients undergoing medial rectus recession and pulley posterior fixation. Early measurements were made within 1 week post operation. Late measurements were at the final visit averaging 3.5 years postoperation. SD = standard deviation.

TABLE 1

Patient characteristics and surgical outcomes.

Patient	Age (yrs)	Pre-operative Near ET Δ	Pre-operative Distance ET Δ	Pre-operative N-D Disparity Δ	Early Postoperative Near ET Δ	Early Postoperative Distance ET Δ	Postoperative N-D Disparity Δ	Late Postoperative Near ET Δ	Late Postoperative Distance ET Δ	Late N-D Disparity Δ	MR Recession OU (mm)	Stereo (arcsec)	Follow-up (yrs)
1	2	25	10	15	10	6	4	0	0	0	3.5	nil	5
2	3	25	18	7	0	8	4	0	0	0	4	40	8
3	4	30	20	10	8	8	0	16	14	2	4	nil	2
4	4.5	40	25	15	8	0	8	2	4	-2	5.5	N.D.	5
5	1.2	16	10	6	0	0	0	4	0	4	4	N.D.	1
6	5	80	30	50	0	6	-6	0	0	0	5.5	nil	6
7	3.8	20	12	8	0	0	0	0	0	0	4	nil	6
8	3.8	75	35	40	0	0	0	0	0	0	6	nil	3
9	3	45	30	15	0	0	0	0	0	0	5	nil	1
10	6	45	30	16	0	0	0	0	0	0	6	nil	5
11	5.5	45	38	7	0	0	0	0	0	0	4.5	600	2
12	1.7	25	0	25	0	0	0	0	0	0	3	400	2.5
13	3.5	18	12	6	10	6	4	0	0	0	3.5	nil	0.5
14	6	25	16	9	0	0	0	2	4	-2	4	3000	8
15	3.8	30	16	14	0	-8	8	1	4	-3	3.5	3000	3
16	6	16	6	10	0	6	-6	8	6	2	3.5	400	3
17	7	16	8	8	0	0	0	0	-6	-6	3.5	400	0.25
18	5.5	45	25	20	0	0	0	8	0	8	4.5	50	3
19	5.5	45	35	10	0	0	0	0	0	0	6	40	3
20	3	65	25	40	4	0	4	0	0	0	5.5	N.D.	3
21	6	45	35	10	0	0	0	-10	0	-10	5.5	50	0.7
Mean	4.3	36.9	19.6	16.4	2.8	1.3	1.5	1.0	0.1	0.9	4.4	---	3.5
Std. Dev.	1.6	18.9	10.5	12.3	5.2	3.3	4.7	6.2	5.8	3.6	0.9	---	2.5