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Radiographic Predictors of Visual Outcome in Orbital Compartment Syndrome

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Abstract

Purpose—The goal of this study is to evaluate parameters on orbital computed tomography as predictors of visual outcome in orbital compartment syndrome from retrobulbar hematoma or orbital cellulitis. The study will assess the assertion that certain patients are anatomically predisposed to vision loss in these conditions.

Methods—A retrospective chart review of consecutive patients with the diagnosis of either orbital cellulitis or orbital hematoma from the clinic of a single provider in an academic practice from 2006 to 2009 was performed. Exclusion criteria included pre-existing vision loss, lack of CT scan for analysis, or lack of one month follow-up for final visual acuity. Measurements of final visual acuity, medial wall length, lateral wall length, distance from globe to apex, and a novel measurement of posterior globe tenting (stretch angle) were obtained. Patients were divided into two groups: normal visual acuity and vision loss. Statistical analysis was performed to identify significant differences between the two groups.

Results—The normal vision group consisted of 11 patients all with vision of 20/30 or better. The average length of the medial and lateral wall was 43.9mm and 41.6mm respectively. The average distance from the globe to the apex was 26.3mm in the uninvolved eye and 30.3mm in the involved eye resulting in an average difference of 4.18mm. The average stretch angle measurement was 28.9° in the uninvolved eye and 28.5° in the involved eye resulting in an average difference of 0.41°.

The vision loss group consisted of four patients all with vision of count fingers or worse. The average length of the medial and lateral wall was 46.9mm and 45.7mm respectively. The average distance from the globe to the apex was 32.2mm in the uninvolved eye and 36.7mm in the involved eye resulting in an average difference of 4.50mm. The average stretch angle measurement was 32.3° in the uninvolved eye and 21.1° in the involved eye resulting in an average difference of 11.2°.

The difference in stretch angle between eyes in the vision loss and normal vision groups were found to be highly significant with a p-value of less than 0.001. The difference between the two orbits for globe to apex is a rough measurement of proptosis and was not statistically different in

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the two groups ($p = .71$). Whereas, the length from the globe to apex in the uninvolved eye was statistically different between the vision loss group and normal vision group ($p < .001$).

Conclusions—Orbital compartment syndrome is a potentially vision threatening condition. Minimal objective data is currently available in the literature to guide physicians in clinical judgment making regarding these patients. The results of this study indicate that comparing the novel stretch angle between the patient's two eyes as well as measuring the length from the globe to orbital apex can help identify patients at risk for poor visual outcome. This study provides objective measurements that can aid ophthalmologist and radiologist in determining the relative threat to vision in patients presenting with orbital compartment syndrome from orbital cellulitis or retrobulbar hematoma. Hopefully, the data can help select patients that may benefit from more aggressive intervention and will ultimately result in superior visual outcomes.

Introduction

Orbital compartment syndrome (OCS) is a potentially vision threatening condition resulting from increased orbital pressure. The orbital walls are formed by seven rigid bones that form a barrier to volume expansion. Anterior displacement of orbital contents including the globe provide for a small amount of compliance. However, as the maximal amount of anterior displacement is exceeded, orbital pressure rises precipitously creating a compartment syndrome. Retrobulbar hematoma and orbital cellulitis are classic examples of conditions that may cause OCS but any condition that results in an increase in mass within the orbit can potentially be a cause. Acute vision loss can arise from central retinal artery occlusion, direct compressive optic neuropathy, or compromise of the optic nerve blood supply.¹⁻²

The diagnosis of compartment syndrome is clinical but differentiating patients at high risk for vision loss at initial visit can be difficult secondary to lid swelling and patient compliance. Attempts have been made to directly measure the orbital compartment pressure but these techniques have not gained widespread use.³⁻⁵ Radiographic evidence of posterior globe tenting has been previously reported as correlating to poor vision by Dalley et al; however, no study to date has been performed to compare globe tenting in conjunction with other radiographic parameters to predict vision loss.

The purpose of this study is to determine if radiographic measurements can provide objective data to help predict patients at risk of vision loss in orbital compartment syndrome from orbital cellulitis and orbital hematoma.

Method

A retrospective chart review of consecutive adult patients with the diagnosis of either orbital cellulitis or orbital hematoma from the clinic of a single provider in an academic practice from 2006 to 2009 was completed. Exclusion criteria included pre-existing vision loss, lack of CT scan for analysis, or lack of one month follow-up for final visual acuity. All measurements were obtained utilizing OsirixTM PACS workstation DICOM viewer. Measurements included medial wall length, lateral wall length, globe to apex distance, and the novel stretch angle (Figures 1–2). The stretch angle is measured by creating an isosceles triangle whose base extends from the midpoint of the optic nerve head to the insertion of the medial rectus muscle to the globe on axial CT image. The apex of the triangle is found geometrically at the point on the sclera that falls on a line extending from the midpoint of the triangle base at a right angle. Data was compiled in an ExcelTM spreadsheet. Patients were divided into two groups: normal visual acuity and vision loss (Tables 1,2). Vision loss was defined as final visual acuity of worse than 20/40. All measurements obtained were compared utilizing Wilcoxon tests between the normal vision and vision loss groups to determine parameters that were predictive of vision loss (Table 3).

Results

The normal vision group consisted of 11 patients all with vision of 20/30 or better. An additional six patients all of which who had normal visual acuity were excluded from the study secondary to a lack of CT images for analysis. The average length of the medial and lateral wall was 43.9mm and 41.6mm respectively. The average distance from the globe to the apex was 26.3mm in the uninvolved eye and 30.3mm in the involved eye resulting in an average difference of 4.18mm. The average stretch angle measurement was 28.9° in the uninvolved eye and 28.5° in the involved eye resulting in an average difference of 0.41°.

The vision loss group consisted of four patients all with vision of count fingers or worse. The average length of the medial and lateral wall was 46.9mm and 45.7mm respectively. The average distance from the globe to the apex was 32.2mm in the uninvolved eye and 36.7mm in the involved eye resulting in an average difference of 4.50mm. The average stretch angle measurement was 32.3° in the uninvolved eye and 21.1° in the involved eye resulting in an average difference of 11.2°.

The difference in stretch angle between eyes in the vision loss and normal vision groups were found to be highly significant with a p-value of less than 0.001. The difference between the two orbits for globe to apex is a rough measurement of proptosis and was not statistically different in the two groups ($p = .71$). Whereas, the length from the globe to apex in the uninvolved eye was statistically different between the vision loss group and normal vision group ($p = <0.001$).

Conclusion

The analysis of the stretch angle indicates that this measurement can be helpful in predicting patients at risk for vision loss. The difference between the involved and uninvolved eye in patients with vision loss was 11.21 degrees. This value contrasts sharply with the difference of 0.41 degrees in patients who retained normal vision. The difference measurement was found to be highly statistically significant with a p-value of less than 0.001. This indicates that the difference in Stretch angle between eyes is a significant predictor of vision loss.

Conventional wisdom teaches that proptosis is a significant clinical finding in the examination of patient's with orbital cellulitis or retrobulbar hematoma. However, the analysis of the difference between the globe to the apex of the orbit in the involved and uninvolved orbits, a rough estimate of proptosis, was not found to be an independent risk factor for vision loss. All patients regardless of final visual acuity experienced roughly the same degree of proptosis.

In contrast, the distance from the globe to the orbital apex in the unaffected eye was found to be strongly predictive of vision loss ($p = <0.001$). All the patients in the vision loss group had longer distances from globe to apex in the uninvolved eye than any of the patients in the normal vision group. This finding suggests that certain patients are anatomically predisposed to vision loss in OCS. The reason for this observation is not exactly clear. It is possible that patients with anteriorly located globes have less excess optic nerve length, limiting the amount of anterior displacement that can be tolerated. It is the authors' belief that an increased globe to orbital apex distance anatomically predisposes this subset of patients to a higher likelihood of optic nerve damage as measured by the increased stretch angle during an orbital compartment syndrome.

Measurement of the lateral and medial wall lengths also revealed a trend toward longer orbits being correlated with vision loss. The trend did not prove to be statistically significant

but the data does suggest that longer orbits are at greater risk for vision loss consistent with the measurement of globe to apex distance.

The study was limited by a small sample size but given the strength of statistical analysis, it is reasonable to expect that the findings will hold up with a larger sample size. Comparison between the orbital cellulitis and retrobulbar hematoma groups was not possible secondary to a lack of adequate sample size.

Orbital compartment syndrome is a potentially vision threatening condition. Minimal objective data is currently available in the literature to guide physicians in clinical judgment making regarding these patients. The results of this study indicate that comparing the novel stretch angle between the patient's two eyes as well as measuring the length from the globe to apex in the uninvolved eye can help predict poor visual outcome.

Lateral canthotomy and cantholysis are the traditional interventions for the treatment of orbital compartment syndrome and should be performed without delay based on clinical findings.⁷⁻⁹ More aggressive interventions such as removal of bone for orbital decompression or orbital septum release have been described but the indications for these procedures are not well defined. This study provides objective measurements that can aid ophthalmologist and radiologist in determining the relative threat to vision in patients presenting with orbital compartment syndrome from orbital cellulitis and retrobulbar hematomas. Hopefully, the data can help select patients that may benefit from earlier and more aggressive intervention that will ultimately result in superior visual outcomes.

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Figure 1.

- a) Medial wall length measured on axial cut at the level of superior orbital fissure from anterior lacrimal crest to medial edge of superior orbital fissure
- b) Lateral wall length measured on axial cut at the level of superior orbital fissure from lateral orbital rim to lateral edge of superior orbital fissure

Figure 2.

- a) Globe to Orbital Apex measured on axial cut at the level of superior orbital fissure from the optic nerve head to the beginning of the superior orbital fissure
- b) Medial Rectus/Optic Nerve Head/Sclera Angle(stretch angle) measured on axial cut at the level of optic nerve head by measuring the angle formed by an isosceles triangle connecting medial rectus insertion, optic nerve head, and sclera

Table 1

Normal Vision Group

Patient	Medial Wall	Lateral Wall	Eye to Apex	Uninvolved Eye	Stretch Angle	Uninvolved Angle	Final Va
1	44.4	43.5	31.9	28.5	23.6	24.2	20/20
2	49.7	45.1	39.7	27.6	23.5	23.8	20/20
3	41.6	46.3	37.9	29.4	21.6	22.3	20/20
4	46	45.4	29.3	29.7	30.8	31.8	20/20
5	45.47	43.22	32.58	28.39	31.8	31.5	20/20
6	42.3	45.5	27.2	28.6	31.5	32.4	20/25
7	42.9	45	24.9	21.9	25.8	25.8	20/30
8	41.4	28.5	22.9	14.7	34.6	35.5	20/30
9	44.4	38.4	29.46	29.3	30.9	29.1	20/25
10	38.4	34.6	28.2	25.8	28	30	20/30
11	45.9	42.5	29.7	23.9	31.1	31.3	20/30
Averages	43.9	41.6	30.3	26.3	28.5	28.9	
			Difference	4.18	Difference	0.41	

Table 2

Vision Loss Group

Patient	Medial Wall	Lateral Wall	Eye to Apex	Uninvolved Eye	Stretch Angle	Uninvolved Angle	Final Va
1	47	44.5	33.5	31.9	17.5	24.8	NLP
2	45.6	42.1	37.4	32.3	27.8	38.5	NLP
3	43.6	44.66	38.4	33.42	20.16	35	NLP
4	51.3	51.4	37.5	31.2	19	31	CF 3'
Averages	46.88	45.67	36.70	32.21	21.12	32.33	
			Difference	4.50	Difference	11.21	

Table 3

Statistical Analysis of Measurements

Measurement	Normal Vision N=11	Vision Loss N=4	p-value
Medial Wall	42.0 44.4 45.7 (43.9±3.0)	45.1 46.3 48.1 (46.9±3.3)	0.12
Lateral Wall	40.5 43.5 45.2 (41.6±5.6)	43.9 44.6 46.3 (45.7±4.0)	0.62
Eye to Apex Uninvolved Eye	24.85 28.39 28.95 (26.16±4.54)	31.72 32.10 32.58 (32.20±0.93)	<0.001
Eye to Apex Difference	1.3 3.4 7.0 (4.2±4.2)	4.1 5.0 5.4 (4.5±2.0)	0.71
Stretch Angle Difference	0.90 0.60 0.10 (0.41±0.95)	12.71 11.35 9.85 (11.21±3.13)	<0.001

a b c represent the lower quartile a, the median b, and the upper quartile c for continuous variables.

x±s represents x±1SD.