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Orbital measurements in patients with non-syndromic craniosynostosis

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Abstract

Context: Congenital craniofacial anomalies are a rare group of disease. Diagnosis and treatment of this condition is important as the patients develop a series of complications affecting their neurological, visual and social development.

Aim: Study the ophthalmic manifestations in patients with non-syndromic craniosynostosis.

Materials and Methods: Patients diagnosed to have non-syndromic craniosynostosis underwent complete ophthalmic evaluation including visual acuity by age appropriate method, cycloplegic refraction, strabismus evaluation, anterior segment and fundus evaluation. Measurement of proptosis, inter pupillary, inter inner canthal and inter outer canthal distances were done.

Results: 28 patients were studied. 13(46.4%) were male and 15(53.6%) were female. Unilateral coronal synostosis was seen in 8 (28.6%) patients, bicoronal synostosis in 4 (14.3%), multiple suture synostosis in 7 (25%) patients, lambdoid synostosis in 2 (7.1%) patients, sagital synostosis in 2 (7.1%) and metopic synostosis in 5(17.9%) patients. 87% of patients had some ophthalmic involvement. Hypertelorism was seen in 10.4% of patients. Hypotelorism was seen in 25% of patients, most of them having metopic synostosis. Telecanthus without bony hypertelorism was seen in 42% of non-syndromic synostosis. The average inter inner canthal, inter orbital distance were more than normal in all patients. The average inter pupillary distance, inter outer canthal distance were less than normal in non-syndromic patients. 2 (7.1%) patients had axial proptosis. Extra-ocular muscle abnormalities were seen in 6 (21.4%) patients. Inferior oblique over action was seen in 5 (17.9 %) patients, Strabismus in straight gaze in 6 (21.4 %) patients, Ametropia was seen in 10 (35.7 %) patients, visual impairment was seen in 3 (10.7%), anterior segment abnormality in 4 (14.3%) and optic disc abnormalities were seen in 9 (32.1%) patients.

Conclusion: Ophthalmic involvement is common in non-syndromic craniofacial synostosis. Ophthalmic evaluation should be an integral part of evaluation of the craniosynostosis patients.

Keywords: Craniosynostosis, Non- syndromic craniosynostosis, Unilateral coronal synostosis

Introduction

Craniosynostosis or premature suture fusion is one of the most common craniofacial anomalies. The prevalence of the disease has been estimated to be about 1 in 2000 to 5000 live births [(1)]. Craniosynostosis can be isolated non-syndromic or it may be part of a larger syndrome with digital malformations, skeletal defect, cardiac defect or other systemic anomalies. The diagnosis and treatment of this condition is important as the patients develop a series of complications affecting their neurological, visual and social development.

The diagnosis of craniosynostosis is by careful clinical examination and cephalometric measurements like head circumference, inter-canthal and inter-pupillary distances. The shape of the head will give a clue as to the possible suture involved with the growth following Virchow's law. Growth is arrested perpendicular to the suture and increased parallel to it. There may also be ridging along the fused sutures.[(1)]

Ophthalmological evaluation in a patient with craniofacial anomalies is mandatory due to the incidence of ophthalmic abnormalities in these disorders, and also because it serves as a reliable indicator for timing of surgery and follow-up. Ocular problems in craniofacial synostosis may either be primary due to the developmental disturbances or secondary as a result of the altered anatomy; they may be structural or functional. Structural manifestations include proptosis, hypertelorism or telecanthus, down-slanting palpebral fissures, ptosis, lacrimal system abnormalities,[(2,4,5,6)] keratoconus, extra-ocular muscle abnormalities and optic nerve abnormalities. Functional abnormalities are refractive errors, amblyopia and strabismus.[(7,8)]

Abnormal protrusion of the eyeball is called proptosis. It can be axial or non-axial depending on the position of the globe. In Indian population a value >19mm or a difference of more than 2 mm between the two eyes is considered abnormal.[(2)] It is mainly a result of midface hypoplasia and shallow orbits.

Increased inter-orbital distance is called hypertelorism. Its measurement is based on the interpupillary and intercanthal (outer and inner) distances for which normal values are available.[(3,4)] Telecanthus or the lateral displacement of the medial canthi without bony hypertelorism may occur. Epicanthal folds and ptosis of various degrees may also occur. Down-slanting palpebral fissure, caused by the asymmetry between the growth of the frontal and maxillary portion of the face is seen in most syndromes.[(5)] Lacrimal duct abnormalities with nasolacrimal duct blockage are also found.

Abnormal movement of the eyes can also be present when there is no structural abnormality. The most common are an apparent Superior Oblique underaction, Inferior Oblique (IO) overaction and Lateral rectus (LR) underaction.[(5,6)]

Patients with craniosynostosis are susceptible to raised intra-cranial tension which can lead to optic atrophy and visual failure. Screening for papilledema is one of the earliest and most reliable methods for detecting raised intracranial tension.[9]

Apart from the structural abnormalities, the visual function in these patients is also compromised. The visual loss in these patients can be ascribed to amblyopia, optic neuropathy or exposure keratitis. Amblyopia could be secondary to uncorrected refractive errors, stimulus deprivation or due to strabismus.[10]

Aims and Objectives

- Orbital measurements and ophthalmic manifestations in patients with non-syndromic craniosynostosis.
- To establish the role of ophthalmic evaluation for non-syndromic craniosynostosis patients.

Materials and Methods

The study was conducted at the Department of Ophthalmology, Amrita Institute of Medical Sciences, Kochi, Kerala on an outpatient basis on patients diagnosed to have craniofacial synostosis based on clinical examination along with computerized tomography.

Each patient underwent a complete ophthalmic evaluation that included age, sex, diagnosis based on the suture with synostosis and associated syndromes, craniofacial procedures done, visual Acuity, cycloplegic refraction, extraocular movements, strabismus measurement, anterior segment abnormalities by slit lamp examination, fundus examination by indirect ophthalmoscopy. Patients with non-syndromic craniosynostosis were included in this study.

Visual acuity was tested for central, steady and maintained if age is ≤ 1 year; with Cardiff visual acuity chart for age 1-3 years, Lea symbols chart for age 3-6 years and Snellen chart for age > 6 years. Visual impairment defined as unsteady or unmaintained fixation in age ≤ 1year or Best corrected visual acuity (BCVA) ≤ 6/12 of Snellen equivalent (Log MAR 0.3) in at least one eye. Amblyopia was defined as a difference of 2 or more lines between the two eyes or visual acuity ≤ 6/12 with no structural abnormalities to explain the same.

All patients underwent retinoscopy after attaining cycloplegia with homatropine 2% eye drops instilled twice 20 minutes apart. Spherical equivalent was derived from the retinoscopy value and was considered for diagnosing refractive errors. Ametropia was diagnosed as explained. Hyperopia if spherical equivalent was ≥ +2D for age more than 5 years and ≥ +3D for age less than 5 years, myopia if the spherical equivalent was ≥ -1.5D, astigmatism if the cylindrical value was ≥ 1.5D and anisometropia if the difference was > 1.5 D between the two eyes. Ductions and versions were checked in all 9 gazes. Strabismus when present was measured with Hirschberg and alternate prism bar cover test. Anterior segment was examined under slit lamp and fundus evaluation was done using indirect ophthalmoscopy.

Interpupillary distance, inter innercanthal and inter outer canthal distance were measured with a transparent millimeter scale. Bony inter orbital distance was measured from the axial cut in Computerised Tomography (CT) (Siemen's 64 slice multi-detected computerized tomography scanner – 1mm axial and coronal cuts) passing through the recti and lens. The distance between points on each lacrimal bone representing the anterior end of the medial orbital wall was taken as the anterior inter-orbital distance.[4] Values published by Lakshminarayana P[3] and Waitzmann A[4] were taken as normal and compared with that of study group. Normal values based on age are given in the Table 1.

Hypertelorism is defined as an increased inter-pupillary distance (IPD) compared to age matched normal. Telecanthus is an increased inter-inner canthal distance (IICD) with normal IPD. A value beyond the higher end of normal range for age matched normal was considered as hypertelorism and below the lower end was considered as hypotelorism.

Proptosis was defined as an exophthalmometry value more than 17 mm for age less than 3 years, more than 19 mm for age more than 3 years or a difference of more than 2 mm between the two eyes. In children less than 2 years of age, globe protrusion was measured from CT scan. Measurement was taken in axial cut in a slice in the orbital region, transecting the lens of the globe, the optic nerve, the ethmoidal air cells, the medial and lateral rectus muscle. Globe protrusion was measured as the perpendicular distance between the anterior tips of the lateral orbital wall and the most anterior point on the globe.[4]

Results

A total of 28 patients with non-syndromic craniosynostosis were studied. There were 13 (46.4%) male and 15 (53.6%) female patients. Age of the patients ranged from 3 months to 23 years with a mean age of 3 years.

8 patients (36.4%) were operated (craniofacial surgery) and 14 (63.6%) were unoperated. Distribution of the non-syndromic synostosis is as in Table 2. In this study unicoronal synostosis was the most common type of non-syndromic synostosis. The diagnosis and measurements are given in Table 3.

87% of patients had at least one ophthalmic manifestation. 8 patients were in the age group of less than 1 year, 13 patients were in the age group of 1 to 3 years and 7 patients were in the age group of above 3 years. The range, mean and standard deviation of orbital measurements are given in Table 4.

3 (10.7%) patients had hypertelorism, 7 (25%) had hypotelorism and 12 patients had telecanthus. Of the 7 patients with hypotelorism 3 had metopic stenosis, 2 had

multiple suture involvement (at least one of which was metopic stenosis), 1 had sagittal synostosis and 1 had coronal synostosis. 3 patients had down slanting palpebral fissures and 2 patients had axial proptosis. 6 patients had extra-ocular muscle abnormalities and of these 5 patients had over action inferior oblique muscle and 1 patient had inferior oblique underaction. 4 patients had esotropia and 2 patients had exotropia.

Ametropia was seen 11 patients of these 5 patients had with the rule astigmatism, 3 patients had irregular astigmatism, 2 patients had myopia, and 1 patient had hypermetropia. Anisometropia was seen in 4 patients. Optic disc changes were seen in 9 patients, papilloedema in 3 patients, unilateral disc oedema in 3 patients and crowded disc (small optic disc with blurred disc margins, not associated with raised intra-cranial tension) in 3 patients.

Unilateral coronal synostosis was the most common non-syndromic synostosis in our study. Distribution of ophthalmic manifestation is given in Table 5. Telecanthus and extra ocular muscle abnormalities were the commonly seen ocular manifestation. 2 patients had esotropia and 1 patient had exotropia. Visual impairment was seen in one patient in the eye contralateral to the side of synostosis, due to anisometropic amblyopia secondary to oblique astigmatism in that eye. Optic disc changes were seen in 2 patients, crowded disc in one patient and disc oedema on the ipsilateral side in the other patient.

Table 1: Normal values for reference based on age

Age	Interpupillary distance(cm)	Interorbital distance (cm)	Inter innercanthal distance (cm)	Inter outercanthal distance (cm)
<1	4.1 - 5.8	1.6 - 2	2.1 - 2.7	6.8 - 8
1 to 3	5 - 6.2	1.8 - 2.1	2.3 - 3	7.6 - 9.2
>3	5.6 - 6.8	2.1 - 2.5	2.6 - 3.1	8.4 - 10

Table 2: Distribution of Diagnosis of non-syndromic craniosynostosis patients

Diagnosis	Number of Patients	Percentage (%)
Unicoronal synostosis	8	28.6
Bi-coronal synostosis	4	14.3
Multi- suture synostosis	7	25
Sagittal synostosis	2	7.1
Lambdoid synostosis	2	7.1
Metopic synostosis	5	17.9

Table 3: Diagnosis and measurements of non-syndromic craniosynostosis patients

Sl No	Age	Sex	Diagnosis	Cranio-facial Surgery	IPD (cm)	IICD (cm)	IOD (cm)	IOCD (cm)	Exophthalmometry (mm)	
									Right Eye	Left Eye
1	0.25	M	SS	Yes	4.3	2.8	2.5	7.5	14	13
2	4	F	UCS	Yes	5.6	3	2	8	17	17
3	1	F	UCS	Yes	5	3	2.06	7.5	12	12
4	2	M	LS	No	6	3	2.2	9	14	14
5	2	M	LS	No	5.5	3.2	2	7.8	13	13
6	0.58	F	MS	No	4.5	2.7	1.7	6.8	10	11
7	1.67	M	MSS	No	4.6	2.3	1.8	7.2	14	13
8	8	M	SS	Yes	5.2	3	1.8	8.5	11	10
9	0.92	F	BCS	No	4	2	1.6	6	14	13
10	0.33	M	UCS	No	5.2	2.8	1.8	7.5	14	13
11	1	F	MSS	No	5	2.5	2	7.5	16	16
12	6	M	MSS	Yes	6.5	3.8	2.8	9.3	18	21
13	1.75	F	MS	No	4.8	3	2	7.5	16	15
14	7	F	MSS	Yes	5	2.5	2	7.5	13	13
15	3	F	BCS	No	5.7	3.5	2	8.5	12	8
16	1	F	MS	No	5	2.8	1.8	7.5	14	13
17	5	M	MSS	No	6	3	2	9	19	18
18	23	F	UCS	Yes	7.5	4.8	3.5	11	24	23
19	0.83	F	BCS	Yes	4.9	2.9	2	7.9	13	13
20	0.92	M	UCS	Yes	5.2	3	2	8	12	12

21	0.75	F	UCS	No	5	3	1.8	7	11	12
22	10	M	MS	No	6	4	3	10	16	15
23	1.5	M	MS	Yes	4.2	3	1.8	6.6	11	12
24	1	M	BCS	No	4.2	2	1.2	6	12	11
25	0.25	F	UCS	No	5	2.5	1.8	7	12	11
26	1.5	M	MSS	No	5.2	3	1.8	8	15	16
27	3	F	UCS	No	5.5	3	2	7.6	16	16
28	2	F	MSS	Yes	6	3.2	2	8.2	14	15
Mean and Standard deviation of measurements (SD in brackets)					5.24 (0.76)	2.98 (0.47)	2.33 (0.47)	7.85 (1.1)	14.19 (2.93)	13.89 (2.18)

Abbreviations used: BCS: Bi-coronal Synostosis, IOD: Inter Orbital Distance, IICD: Inter Inner Canthal Distance, IPD: Inter Papillary Distance, IOCD: Inter Outer Canthal Distance, LS: Lambdoid Synostosis, MS: Metopic Synostosis, MSS: Multi-suture Synostosis, SS: Sagittal Synostosis, UCS: Unicoronal Synostosis

Table 4: Distribution of ophthalmic manifestations in Unilateral coronal synostosis

Ophthalmic manifestation	Frequency (n = 8)	Percentage (%)
Hypertelorism	1	12.5
Telecanthus	4	50
Down-slanting palpebral fissure	1	12.5
Axial proptosis	1	12.5
EOM Abnormality	4	50.0
Strabismus in primary gaze	3	37.5
V pattern	1	12.5
Ametropia	2	25.0
Visual impairment	1	12.5
Optic disc changes	2	25.0

Table 5: Statistical analysis of orbital measurements

Age Groups	IPD			IICD			IOD			IOCD		
	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
Less than 1 year	4 - 5.2	4.763	0.444	2 - 3	2.713	0.331	2.6 - 2.5	1.9	0.278	6 - 8	7.212	0.653
1 - 3 years	4.6 - 6	5.2	0.481	2.3 - 3.5	2.913	0.38	2.8 - 2.2	1.987	0.136	7.2 - 9	7.813	0.615
Above 3 years	5 - 7.5	5.85	0.855	2.5 - 4.8	3.363	0.767	1.8 - 3.5	2.363	0.646	7.5 - 11	8.85	1.234

Abbreviations used: IOD: Inter orbital distance, IICD: Inter Inner Canthal Distance, IPD: Inter Papillary Distance, IOCD: Inter Outer Canthal Distance, SD: Standard Deviation

Table 6: Comparison of ophthalmic manifestations in unilateral coronal synostosis

Variable	Present study (%) n=8	Pensler JM et al (%)n=45
Ophthalmic abnormality	87.5	72.0
Strabismus	37.5	52.0
Visual impairment	12.5	6.0
Ametropia	25.0	27.3
Optic disc changes	25.0	0.0

Discussion

Unlike the studies reported till now[11,12,13] that states that sagittal synostosis to be most common type of synostosis, our study found unilateral coronal synostosis to be the most common type of non-syndromic synostosis and coronal synostosis to be the most common type of synostosis.

We have in this study, analysed the ophthalmic involvement of patients with non-syndromic craniosynostosis and compared the orbital measurements with that of normal. To the best of our knowledge and understanding, this is the first study in India that gives a compiled data on ophthalmic manifestations in non-syndromic craniosynostosis.

Pensler JM et al[14] studied ocular manifestations in 45 patients with unilateral coronal synostosis pre and post- operatively. 52% had extraocular muscle abnormality pre-operatively, of which 21% showed a change post operatively, 72% of patients had at least some ophthalmic abnormality post operatively. Visual impairment was seen in 6% and ametropia in 27.3%.

Gupta et al[15] studied astigmatism and strabismus in 156 patients with non-syndromic plagiocephaly. 45 patients had synostotic plagiocephaly and 111 had deformational plagiocephaly. They found that astigmatism was seen in 28% of synostotic plagiocephaly and strabismus in 9%, exotropia being more common. In deformational plagiocephaly the findings were similar to normal population.

Some ophthalmic abnormalities were seen in 87.5% patients in our study compared to 72% in study published by Pensler JM et al.[14] Comparison of ophthalmic manifestation in unilateral coronal synostosis is given in Table 6. Hypertelorism and proptosis was seen in 12.5% of patients and telecanthus in 50% of patients with unilateral coronal synostosis in the present study. Strabismus, ametropia and visual impairment were comparable with that seen in the study done by Pensler JM et al,[14] but strabismus reported by Gupta et al[15] was less (9%). Ametropia was due to astigmatism in the present study which is similar to the other 2 studies. Esotropia was more common (25%) than exotropia (12.5%) compared to Gupta et al, who found exotropia more common. Extra ocular muscle abnormalities were seen in 50% of patients, mostly inferior oblique over action. Visual impairment was seen in 12.5% of patients and was unilateral and due to anisometropic amblyopia secondary to oblique astigmatism in the eye contralateral to the side of the synostosis. This is as stated by Levy et al[16] who found that astigmatism was common in unicoronal synostosis and more in the contralateral eye; and Tarczy-Hornoch K et al[17] who found anisometropic amblyopia in the contralateral eye due to oblique astigmatism. Optic disc changes were seen in 2 patients, 1 with unilateral disc edema and in the ipsilateral side and the other with a crowded disc. No patient had optic atrophy as stated in other studies.

Other non-syndromic synostosis: Metopic synostosis was the second most common single suture synostosis, following unilateral coronal synostosis. Hypotelorism was more common in metopic synostosis. Proptosis, hypertelorism, anterior segment and optic disc abnormalities were more common in multi suture synostosis. Strabismus, ametropia and amblyopia (strabismic or ametropic) was common in single suture synostosis.

Limitations

A representative sample of each synostosis could not be collected. Amblyopic and hence visual impairment could have been under diagnosed as the visual acuity was based on symbol charts in ages <6 years. Strabismus could have been underestimated as it is difficult to obtain measurements in these patients. Pattern-reversal visual evoked potentials were not taken into consideration in assessing the visual function.

Conclusion

Craniofacial synostosis patients have a significant involvement of the eye and the orbit. It can cause both structural and functional abnormalities. Hypotelorism and telecanthus are common in non-syndromic craniosynostosis. Ophthalmic manifestations in non-syndromic synostosis are usually functional with more of ametropia, strabismus or visual impairment due to amblyopia. Management of craniosynostosis patients requires a multi-disciplinary approach and in this the ophthalmologist plays a critical role.

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