Prevalence of astigmatism in a paediatric population with malocclusions

**ABSTRACT**

**Aim** The purpose of this study was to investigate the prevalence of astigmatism among a paediatric population. **Materials and methods** A total of 322 consecutive patients of the department of Orthodontics and Gnathology, Dental Clinic, University of L’Aquila, were enlisted for the study and 176 were selected according to the exclusion criteria. Pre-treatment diagnostic data, which included radiographic cephalometric and dental cast evaluation, were recorded and presence of malocclusion was assessed through an ophthalmological examination. Differences in the prevalence of astigmatism by sex and malocclusion were analysed by using the $\chi^2$ (Pearson’s chi-square test) and Fisher’s exact tests. **Results** According to the sagittal malocclusion, patients were classified as Class I (N=122), Class II Division 1 (N=26), Class II Division 2 (N=9), or Class III (N=19); according to the transverse malocclusion patients were classified into cross-bite (N=39) and no cross-bite (N=137) groups; after ophthalmological examination astigmatism was detected in 32 patients (18.18%). Statistically significant correlations were found between astigmatism and cross-bite ($p < 0.0001$), while no associations were found with other malocclusions. No gender influence was found for astigmatism or malocclusion. **Discussion** Few study investigated a possible relationship between the ocular and stomatognathic system, and no data are available in the scientific literature. A higher prevalence of astigmatism was found in patients with cross-bite: as expected no other significant association was found. The relationship between astigmatism and cross-bite could be either related to a specific skeletal pattern, which could induce visual alterations, or to the effect of abnormal visual input on the postural system, which could induce stomatognathic alterations. **Conclusion** The findings of the present study suggest a possible association between astigmatism and cross-bite, but future studies are needed to confirm and explain this observation.

Keywords: Astigmatism; Cross-sectional study; Epidemiology; Malocclusion.

**Introduction**

Astigmatism is defined as impaired eyesight resulting usually from irregular conformation of the cornea; this refractive condition determines impairment of the optical system of forming a point image for a point object [Grosvenor, 2007]. The aetiology involves both cornea and, rarely, the lens: corneal modification could be due to a particular conformation with different warp values in correspondence of its orthogonal meridians (regular astigmatism) or secondary to post-traumatic or post-inflammary scar processes, but it could also arise during degenerative processes (i.e. keratoconus, irregular astigmatism); lens modification, congenital or acquired, contribute to the development of the visual defect [Azzolini et al., 2010].

Although genetic visual defects are the most influential, aetiological events in the prenatal and postnatal periods have also been called for anomalies in lens dimension, morphology and position of foramina structure [Angi et al., 1993; Holberg et al., 2006; Teikari et al., 1989]; this finding could be supported by a recent study [Mutti et al., 2004; Read et al. 2007; Mutti et al. 2009] that reported this visual defect since the early infancy (3 months). Prevalence of astigmatism varies on the basis of the geographical areas investigated by the studies [Chan et al., 1983; Dobson et al., 1984; Howland et al., 1984; Zhan et al., 2000; Ibironke et al. 2011], and racial variations are known to influence the prevalence and degree of astigmatism [Lam et al., 1991; Kleinstein et al., 2003; Pan et al. 2011; Fozailoff et al. 2011; Lai et al. 2010]. The reported prevalence of this refractive error in children is quite variable too, and is influenced by age [Fan et al., 2004; Giordano et al. 2009], without any gender difference. A recent study confirmed ethnic and racial variation of astigmatism, reporting an overall prevalence of 11.17% in a sample with an age range of 6-15 years [Pi et al., 2010]. Heikkinen et al. [2002] reported a significant association between strabismus and mesio-distal size of deciduous teeth, in the same hemifacial side; the authors speculated that asymmetries in the head might influence the dentition, considering the common embryonic origins and timing of development [Heikkinen et al., 2002]. Several studies have been published on the prevalence of visual defects in the general population, but no study investigated the associations of visual defects with malocclusions. An anatomical [Gautam et al., 2007] and neurological [Diagne et al., 2006; Zhou et al., 2004] link among the stomatognathic and ocular systems have been reported; in addition the visual input effect on surface electromyographic activity of sternocleidomastoid and masseter muscles at rest has been proved too [Shafiri et al., 1998]; therefore, a pathogenic link between visual and stomatognathic components is likely to exist. Therefore, the aim of the present investigation is to assess the prevalence of the astigmatism in a group of Caucasian orthodontic patients.
Materials and methods

The study was conducted in the dental clinic of the University of L’Aquila, L’Aquila, Italy, on 322 consecutive caucasian patients (155 male, 167 female) of the department of Gnathology. Patients were enrolled for the study between September 2009 and October 2010. All the subjects had pre-treatment panoramic and latero-lateral x-rays, made with the same x-ray device (Siemens, OP10E, Palomex Instrumentarium, Tuusula, Finland). Diagnostic records, anamnestic questionnaire, latero-lateral and panoramic x-rays as well as dental casts were evaluated. Patients with syndromes, severe orthodontic treatment history, and missing any permanent teeth due to extraction were excluded. The patients were all submitted to an ophthalmological examination for evaluation of astigmatism. The subjects presenting combined visual defects or visual defects other than astigmatism (i.e. myopia, hyperopia or strabismus) were excluded to avoid any confounding factor about the prevalence of each visual defect.

A total of 146 subjects, 65 male and 81 female were excluded for presenting other or combined visual defects, history of severe orthodontic treatment and past extraction of permanent teeth; the remaining 176 subjects (75 male, 101 female), were included in the study. The mean age of the patients was 12.4 ± 2.1 years (range, 10-14 years).

The orthodontic conditions were classified as follows: Class I (= ANB angle 0° to 4°, Class I molar relationship), Class II Division 1 (=ANB angle >4°, Class II molar relationship), Class II Division 2 (=ANB angle >4°, Class II molar relationship, deep bite), Class III (=ANB angle <0°, Class III molar relationship); orthodontic diagnosis was mainly performed on the basis of lateral x-rays. According to the presence of cross-bite, the subjects were classified into cross-bite group and no cross-bite group. All records were examined by the same expert clinician (A.M.), who was blind to patient data and ocular condition, in order to eliminate inter-examiner differences and examiner bias.

The study was approved by the Ethics Committee of the University of L’Aquila (Prot. No. 56/2006) and a signed informed consent was obtained from all the parents of the enrolled subjects.

Statistical analysis

Repeatability was tested on 20 randomly selected subjects examined at least 2 weeks after the initial examination. Cohen’s kappa test coefficient was calculated to determine the reliability of determining each dental anomaly in the 2 evaluation periods.

Pearson’s chi-square and Fisher’s exact test were conducted to assess the association between visual defects and malocclusion. An analysis of the influence of sex on the prevalence of astigmatism in the total sample was performed. To study the association between astigmatism and malocclusion subtype, the prevalence of this visual defect in non-malocclusion and malocclusion groups was assessed. Then an analysis for class of malocclusion (sagittal or horizontal) was performed. Since the sagittal class of malocclusion included 3 subclasses (II/1 Class, II/2 Class and III Class) an analysis of the prevalence of visual defects into the sagittal malocclusion group also was conducted. Statistical analysis was performed with SPSS software (version 11.0, SPSS, Chicago, Ill). The statistically significant level of p <0.05 was assumed.

Results

A kappa score of 0.97, which indicated perfect agreement between the first and second evaluations, was recorded for each dental anomaly. This showed the reliability of the recordings.

A total of 32 subjects (18.18%) had astigmatism, while 144 (81.82%) had no visual defects; 122 patients showed Class I (69.31%), 26 showed Class II Division 1 (14.77%), 9 patients presented Class II Division 2 (5.11%) and 19 patients showed Class III (10.79%); 39 patients presented cross-bite (22.15%), while 137 patients (77.84%) did not present transverse malocclusion. In Class I group 19.67% of patients presented astigmatism, while in sagittal malocclusion group (II/1 Class, II/2 Class and III Class) 14.81% of patients had astigmatism. In the cross-bite group 51.28% of the patients had astigmatism, while in the non cross-bite group only 8.76% of patients had astigmatism. The results of the study are shown in Table 1.

| Class | Male | Female | Class I | Class II Division 1 | Class II Division 2 | Class III | Cross-bite Unilateral cross-bite Bilateral cross-bite No cross-bite |
|-------|------|--------|---------|-------------------|-------------------|-----------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Astigmatism | 16 (21.33%) | 16 (15.84%) | 24 (19.67%) | 6 (23.07%) | 0 (0%) | 2 (10.52%) | 20 (51.28%) | 16 (57.14%) | 3 (30%) | 12 (8.75%) |
| Normal | 59 (78.67%) | 85 (84.16%) | 98 (80.33%) | 20 (76.93%) | 9 (100%) | 17 (89.48%) | 19 (48.72%) | 12 (42.86%) | 7 (70%) | 125 (91.25%) |
| Total | 75 (100%) | 101 (100%) | 122 (100%) | 26 (100%) | 9 (100%) | 19 (100%) | 39 (100%) | 28 (100%) | 10 (100%) | 137 (100%) |

* Statistical test performed with Fisher’s exact test

X² Test NS NS NS NS NS NS p <0.0001 NS NS NS

TABLE 1 - Results of the study.
No differences were recorded when analysing the influence of sex on the prevalence of astigmatism (p >0.05). No significant differences were found for prevalence of astigmatism in sagittal malocclusion subclasses; a statistical significant difference was found in the transverse malocclusion: patients presenting cross-bite showed a higher prevalence of astigmatism compared to the patients without cross-bite (p <0.0001); however no differences were detected between unilateral and bilateral cross-bite group. All statistical comparisons were performed with Pearson's χ² test, except for comparison in Class III malocclusion, which was tested with Fisher's exact test.

Discussion

The refractive error is recognised as one of the most important causes of correctable visual impairment accounting for nearly 80% of the visual impairment in persons aged 12 years and older in the United States [Vitale et al., 2008]. The prevalence of visual defects is highly variable as assessed by the presence of several population studies. With the exception of a study in which the high distribution of astigmatism in American Indian children was attributed to the Mongoloid facial characteristics in this population [Lye et al., 1972], with higher lid tension, there is lack of studies about the prevalence of astigmatism in relation to the skeletal facial structure. Moreover, in the orthodontic literature there are no studies reporting the occurrence rate of visual defects compared to malocclusion classes.

Because of the differences in the reported prevalence of visual defects in various racial and ethnic groups, only caucasian orthodontic patients were considered for the present investigation. In this study, 18.18% of the total study population had astigmatism. There were more female subjects in the total sample. While some authors reported significant differences by sex [Jobke et al., 2008], others found non significant differences [Fan et al. 2004]. In our study no statistically significant correlation was observed between sex and astigmatism.

In this study, the prevalence range of this defect ranged from 19.67% in non-malocclusion subjects to 14.81% in the sagittal malocclusion group, and this difference was not statistically significant. According to the sagittal classification of malocclusions, no differences were detected for sagittal malocclusion subclasses. With regard to transversal malocclusions, a higher prevalence of astigmatism was found in the cross-bite group compared to the no cross bite one (51.28% VS 8.76%), and this difference was statistically significant (p <0.0001). In addition this finding was not confounded by the presence of sagittal malocclusion.

The prevalence of astigmatism in this study (18.18%) was higher than the rates reported in general population studies in adults [Atkinson et al., 1980]. This supports the evidence of a disorder that is most prevalent in childhood [Fan et al., 2004].

The results of this study suggest an association between astigmatism and cross-bite malocclusion. According to Heikkinen et al. [2009], it can be speculated that a specific skeletal pattern could determine an altered development of the structures linked with vision, considering the common embryonal origin. For example, recent studies demonstrated that deformational posterior plagiocephaly can affect visual development in a quantifiable manner [Siatkowsky et al., 2005] and that in children with non-syndromic craniosynostosis the presence and severity of visual impairment is related to the type of craniosynostosis [Ricci et al., 2007]. We can even suppose that the association between visual defects and dental malocclusion could be the result of some global development delay [Vitale et al., 2006] or that a visual defect could affect the growth of skeletal and dental structures by altering the postural system. However, the prevalence of environmental rather than genetic factors in the aetiology of visual defects seems to be confirmed [Angi et al., 1998; Teikari et al., 1989]. Further investigations are needed to better understand the mechanisms that could support these findings.

Conclusion

Significant differences between cross-bite and normal transversal occlusion were found in the prevalence of astigmatism. No correlation with any of the sagittal malocclusion class or with sex was found. Astigmatism should be considered in the knowledge of aetiology, diagnosis and treatment of malocclusions. Furthermore, investigation about malocclusions and visual defects should be conducted to define other associations. Further studies are needed to investigate possible mechanisms and physiopathological patterns that could explain the findings of the present study.

References


