

# The relationship between extremity fractures and visual impairment in childhood: A case–control study

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## ABSTRACT

**BACKGROUND:** Fractures are common extremity injuries in pediatric orthopedic practice. The aim of this study is to determine the relationship between pediatric extremity fractures and visual impairments.

**METHODS:** Thirty pediatric patients who were admitted to the emergency and orthopedics and traumatology clinic due to an extremity fracture after a fall were included in the study. Following fracture treatment, the patients were evaluated in terms of ocular findings before discharge from the hospital. Thirty age- and sex-matched healthy children who presented to the ophthalmology department for routine care were also recruited as the control group. All participants underwent a comprehensive ophthalmologic examination, including cycloplegic refraction, visual acuity levels, and near stereoacuity measurement.

**RESULTS:** The number of male participants was higher in both groups. There was no significant difference between the groups in terms of age and gender distribution. The most common upper extremity fractures were observed to be distal radius (52%) and distal humerus fractures (28%). The number of patients who had a refractive error that required spectacles was significantly higher in the fracture group ( $p=0.039$ ). When the visual acuity levels of the better eye were evaluated, the mean visual acuity was significantly lower in the fracture group ( $p=0.016$ ). The mean stereoacuity was also significantly lower in the study group ( $<0.001$ ). In the binary logistic regression analysis model, low stereopsis levels were associated with the risk of pediatric extremity fractures (95% CI: 1.056–1.385;  $p=0.006$ ).

**CONCLUSION:** Our study showed that low-energy pediatric extremity fractures are more common in children with visual impairments that require treatment, and low stereopsis is a risk factor for fractures. Consequently, regular eye examinations and early treatment of visual impairments in children may help to prevent fall-related injuries.

**Keywords:** Childhood; extremity fracture; stereopsis; visual impairment.

## INTRODUCTION

Extremity fractures, one of the leading causes of hospitalization and surgery after injuries in childhood is common in pediatric orthopedic practice.<sup>[1,2]</sup> Most pediatric fractures are caused by mild-to-moderate trauma during fall from height, simple fall, physical sports, fights or playground activities, bicycle-related accidents, motor vehicle accidents, and pedestrian accidents.<sup>[3]</sup>

The previous studies demonstrated the high risk of falls in visually impaired adults.<sup>[4,5]</sup> Several factors are thought to be responsible for the association between poor binocular vision and the increased risk of musculoskeletal injuries, fractures, or falls. First of all, binocular visual impairments are often associated with reduced depth perception which may lead to falls and injuries. In addition, the presence of diplopia or visual

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confusion may increase the risk of injury due to difficulties in fixating on objects, tracking moving objects, and perceiving spatial relationships in these patients.<sup>[6]</sup>

Studies evaluating the causes of extremity injuries in pediatric patients have generally focused on the psychosocial characteristics of children.<sup>[7-10]</sup> The most frequently investigated psychiatric disease associated with pediatric extremity fractures was attention deficit and hyperactivity disorder (ADHD).<sup>[8]</sup> Both inpatient and outpatient treatment of pediatric fractures result in serious socioeconomic costs, so identifying the risk factors in children to reduce the incidence of pediatric fractures is crucial.<sup>[11]</sup>

The aim of the present study was to determine the relationship between pediatric extremity fractures and visual impairments, which has not been previously investigated in the literature. The hypothesis was that the extremity fractures were more common in visually impaired children. Early diagnosis and the treatment of visual impairments in children could reduce the incidence of pediatric extremity fractures and prevent the resulting socioeconomic burden.

## MATERIALS AND METHODS

This cross-sectional and case-control study was conducted at University Training and Research Hospital Orthopedics and Traumatology Clinic between October 2020 and May 2021. The study was performed in accordance with the tenets of the Helsinki Declaration and was approved by the University Faculty of Medicine Clinical Research Ethics Committee (Approval Number: 2020/174). Written informed consent was obtained from the parents or legal representatives of all participants.

Pediatric patients aged between 5 and 16 years, who presented to the orthopedics and traumatology department for a fall-related upper or lower extremity fracture and whose treatments were completed, were included in the study. Following fracture treatment, all patients who met the inclusion criteria were referred to the ophthalmology department before discharge from the hospital. Thirty age- and sex-matched otherwise healthy children who presented to the ophthalmology department for routine care were also recruited as the control group. Participants with mental disability, chronic diseases that may predispose to fractures (such as osteogenesis imperfecta or endocrinological disorders), neurodegenerative diseases, developmental or psychiatric disorders, and those who could not cooperate with ocular examination were excluded from the study. Patients with fractures due to traffic accidents or falls from height were also excluded from the study. The localization (upper/lower extremity, distal/shaft/proximal fracture) and type of fracture, past fracture history, the activity causing the fracture, type of treatment (surgery or closed reduction), and hospitalization requirement of patients were recorded.

In both groups, the time of the last eye examination of the participants, the history of ocular disease, regular use of spectacles, and whether they were wearing their spectacles at the time of fall were recorded. All participants were asked to wear their spectacles if any, and visual acuities were measured using the Snellen chart. Then, Snellen scores were converted into logarithm of minimal angle of resolution notation for statistical analysis. All children underwent a comprehensive ophthalmologic evaluation, including near stereoacuity measurement, cycloplegic refraction, intraocular pressure measurement, slit-lamp biomicroscopy, and dilated fundus examination. Cycloplegic refraction was measured using an autorefractometer (Tonoref III, NIDEK Co., Ltd., Tokyo, Japan) 30 min after instillation of 1% cyclopentolate hydrochloride (Sikloplejin®, Abdi Ibrahim Pharmaceuticals, Istanbul, Turkey) twice at an interval of 5 min. Stereopsis was evaluated with Titmus test in normal room lighting before pupillary dilation. Stereopsis >100 s of arc was considered good stereopsis. The better-seeing eyes of the participants were included in the analysis of visual acuity and refractive error. All evaluations were performed by the same experienced ophthalmologist.

## Statistical Analysis

The sample size is based on the literature of the observed difference in refractive error on extremity fracture in childhood. A power of 80% and a confidence level of 95% yielded the sample size. All data were analyzed using the SPSS statistical software package, version 21.0 (SPSS Inc., Chicago, IL, USA). The Kolmogorov-Smirnov test was used to check the normality of the data distribution. Categorical variables were expressed as frequency and percentage and compared using Pearson's Chi-square test. The Mann-Whitney U test was used when evaluating nonparametric variables that did not show normal distribution between the two groups. Factors associated with the risk of fractures were examined by a binary logistic regression analysis. Odds ratios and 95% confidence intervals were calculated to describe the effect of refraction, stereopsis, and visual acuity on fracture prevalence.  $p < 0.05$  was considered statistically significant.

## RESULTS

Thirty of 41 pediatric patients who were admitted to the orthopedics and traumatology department due to an extremity fracture after a fall were included in the study. The demographics and clinical characteristics of all participants are shown in Table 1. There were no significant differences between groups in terms of age and sex distribution ( $p > 0.05$ ). The number of male participants was high in both groups.

Patients with the hypermetropic refractive error were higher in the fracture group. When the visual acuities of the better eye were evaluated, the mean visual acuity was significantly lower in the fracture group ( $p = 0.016$ ). The mean stereoacuity was also significantly lower in the study group compared to the

**Table 1.** Demographic and clinical characteristics of the patients

Parameter	Fracture group (n=30)	Control group (n=30)	p-value
Age (years) (mean±SD)	10.77±2.94	11.00±3.25	0.778 <sup>a</sup>
Gender (Male/Female)	20/10	18/12	0.592 <sup>b</sup>
Visual acuity (logMAR) (mean±SD)	0.10±0.19	0.02±0.05	0.016 <sup>a</sup>
Stereopsis (seconds of arc) (mean±SD)	53.52±80.22	29.38±46.59	<0.001 <sup>a</sup>
Spherical equivalent (D) (mean±SD)	0.258±1.820	-0.408±0.666	0.033 <sup>a</sup>

D: Diopter; SD: Standard deviation; logMAR: Logarithm of minimal angle of resolution. <sup>a</sup>Mann-Whitney U test, <sup>b</sup>Chi-square test.

**Table 2.** Visual outcomes during examination in cases and control group

Characteristic, n (%)	Fracture group (n=30)	Control group (n=30)	p-value <sup>a</sup>
Visual acuity (Snellen chart)			
<20/40	3 (10)	2 (6.67)	0.640
20/40-20/25	2 (6.67)	0	0.150
>20/25	25 (83.33)	28 (93.33)	0.228
Stereopsis, >100	4 (13.33)	2 (6.67)	0.389
Ophthalmologic examination in past 2 years	15 (50)	11 (36.67)	0.297
Refractive error	19 (63.33)	11 (36.67)	0.039
With spectacles	9 (30)	5 (16.67)	0.222

<sup>a</sup>Chi-square test.

**Table 3.** Factors associated with the risk of extremity fracture

Variables	Odds Ratio (95% CI) <sup>a</sup>	p-value
Visual acuity	0.021 (0.000–1.367)	0.070
Stereopsis	1.209 (1.056–1.385)	0.006
Spherical equivalent	2.015 (0.987–4.112)	0.054

<sup>a</sup>Binary logistic regression analysis. CI: Confidence interval.

control group ( $p<0.001$ ). About 25 (83.33%) of all fractures were upper extremity and 5 (16.67%) were lower extremity fractures. The most common upper extremity fractures were distal radius (52%) and distal humerus fractures (28%). While the surgery was performed in 10 (33.33%) patients, 20 (66.67%) patients were treated with plaster casts. Three (10%) patients had a previous history of extremity fracture.

There was no difference between groups in terms of visual acuity worse than 20/25 ( $p>0.05$ ) (Table 2). The number of patients who had a refractive error that required spectacles was significantly higher in the study group ( $p=0.039$ ). In the fracture group, 9 (30%) patients were already using spectacles regularly, but 6 (20%) of these spectacles were not adequate. When the participants were evaluated for the presence of

good stereopsis, there was no significant difference between the groups ( $p=0.389$ ) (Table 2).

When we questioned whether an ophthalmologic examination was performed in the past 2 years, there was no significant difference between the groups ( $p=0.297$ ). There were no strabismus, anterior, or posterior segment pathologies that could affect vision in the participants. In the binary logistic regression analysis model, low stereopsis levels were associated with the risk of pediatric extremity fractures (95% CI: 1.056–1.385;  $p=0.006$ ) (Table 3).

## DISCUSSION

There is an increase in the frequency of fractures in children due to instances such as poor nutrition, the rising rate of traffic accidents, the increasing young population, and the insufficiency of playgrounds to meet the growing demand.<sup>[11]</sup> The previous studies showed a greater risk of falls and fractures in visually impaired adults and elders.<sup>[4,6]</sup> Although it makes sense to assume that those children with poor vision are more prone to accidents and falls, there are no studies evaluating the relationship between pediatric extremity fractures and visual impairments. In the present study, we showed that treatable ocular disorders causing poor vision in children, especially refractive errors, may be associated with pediatric extremity fractures.

Fractures, accounting for approximately 10–25% of all pediatric injuries, are important public health problems as they cause a restrictive effect on daily life activities of children.<sup>[12,13]</sup> Pediatric fractures may vary by age, sex, season, and time of day. Issin et al.<sup>[14]</sup> demonstrated a male/female ratio of 1.84, and a mean age of 7.1 for boys and 8.6 for girls in pediatric fractures in Turkey. In that study, distal radius fractures with a rate of 26.4% were the most common ones, followed by distal humerus fractures with a rate of 13%.<sup>[14]</sup> Similarly, in our study, fractures were more common in males, with a male/female ratio of 2.0 and a mean age of  $10.77 \pm 2.94$  in the fracture group. In addition, the most common injuries in the study group were distal radius fractures (52%), and distal humerus fractures (28%), respectively. In our study, 56.67% of patients were hospitalized and 33.33% of them underwent surgical treatment. Hospitalization was reported as accounting for the majority of the treatment costs in pediatric fractures.<sup>[15]</sup> The economic burden of fractures may be avoided with the diagnosis and treatment of preventable causes such as visual impairment.

Previously, genetics, risk-taking behavior, obesity, psychiatric disorders, and less milk consumption have been reported as risk factors in pediatric fractures.<sup>[3,16–19]</sup> Children with mental illnesses are believed to have an increased risk of injury and ADHD is the disease most closely associated with the risk of childhood injury.<sup>[1,19]</sup> Duramaz et al.<sup>[20]</sup> found that children with extremity fractures had greater symptoms of ADHD, anxiety, and depression compared to the non-traumatic population. Guo et al.<sup>[1]</sup> reported that ADHD should be listed among the risk factors for pediatric fractures in every sex and age group. They also emphasized that parents, teachers, and caregivers of children with ADHD should be more careful.<sup>[1]</sup> Studies have shown that visual impairment is a risk factor for adult fractures. Coleman et al.<sup>[21]</sup> reported that older women with binocular visual field loss fell more often, and the more severe the visual field loss, the greater the risk of recurrent falls, regardless of age. Pineles et al.<sup>[6]</sup> stated that elder patients with binocular visual impairment had a 27% higher risk of musculoskeletal injury, fracture, or fall. We hypothesized that visual impairment in children may also be a risk factor for pediatric fractures. The visual acuity and stereopsis were lower in children with extremity fractures compared to the control group, and the rate of refractive errors requiring spectacle prescription was higher, in our study.

Some researchers suggested visual impairment as a risk factor for falls and traumatic injuries by disrupting the balance system.<sup>[22,23]</sup> However, there is no study focusing on low vision and traumatic injuries in childhood, in the literature. Webber et al.<sup>[22]</sup> reported functional deficiencies in children with amblyopia in activities requiring hand-eye coordination and rapid movement. Kelly et al.<sup>[23]</sup> determined a reduced development of motor skills, 3–6 times higher probability of motor impairment in children with amblyopia and strabismus, and low scores in balance tests, especially in amblyopic children. In

our study, there was no difference between groups in terms of visual acuity worse than 20/25. However, the lower mean visual acuity in children with extremity fractures supports the previous studies reporting a significant relationship between visual acuity and fractures.

Ivers et al.<sup>[24]</sup> showed that 40% of patients with hip fractures in the elderly had reduced vision and low stereopsis. They also identified an increased risk of fractures associated with ocular factors such as poor vision, decreased depth perception, not wearing spectacles at the time of the fall, and increasing time since the last eye examination.<sup>[24]</sup> Similarly, we found an association between reduced stereopsis and increased risk of fractures. Although nine patients with extremity fractures had spectacles, five of them were not wearing their glasses during the fall, in our study. Contrary to Ivers et al.'s results, the time of the last eye examination was not significantly different between our study groups. Better compliance with periodic ocular examinations in children may be the reason for this result. However, since the eyes continue to grow during childhood, the increases in refractive errors may be faster. Therefore, an increase in refractive errors and inadequacy of the existing spectacles that may lead to falls can occur in the intervals between ocular examinations. The high rate of glasses prescription in the fracture group may indicate the inadequacy of existing spectacles, in our study.

Stark et al.<sup>[25]</sup> found that children living in deprived areas have higher fracture rates than those from affluent areas. The lack of data on the socioeconomic status and lifestyle of the families were the limitations of our study. We, therefore, could not evaluate the effect of these factors on extremity fractures. Another limitation of our study was the limited sample size and that the control group consisted of children presented to the ophthalmology department for routine examination. This may limit the generalization of our results to the pediatric population. Selecting the control group from a school rather than an outpatient clinic would have been more beneficial in terms of the comprehensiveness of the results. In our study, the patients underwent ocular examination shortly after the fracture. Although the lack of prospective follow-up is a limitation of our study, it will contribute to the literature as it is the first study to evaluate the effect of stereopsis and visual impairment in pediatric extremity fractures.

## Conclusion

As rising health-care costs are an ever-present challenge, efforts should be made to seek ways to reduce costs without sacrificing quality patient care. Our study showed that low-energy pediatric extremity fractures are more common in visually impaired children, and low stereopsis is a risk factor for extremity fractures. Consequently, regular eye examinations and early treatment of visual impairments in children may help to prevent fall-related injuries and reduce the costs of pediatric extremity fractures. More comprehensive

prospective studies with a large number of participants are needed to evaluate the effect of visual impairments on fractures in children.

**Ethics Committee Approval:** This study was approved by the Ordu University Faculty of Medicine Clinical Research Ethics Committee (Date: 03.09.2020, Decision No: 2020/174).

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ORJİNAL ÇALIŞMA - ÖZ

## Çocukluk çağındaki ekstremite kırıkları ile görme bozukluğu arasındaki ilişki: Olgu-kontrol çalışması

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**AMAÇ:** Kırıklar, pediatrik ortopedi uygulamasında sık görülen ekstremite yaralanmalarıdır. Bu çalışmanın amacı, çocuk ekstremite kırıkları ile görme bozuklukları arasındaki ilişkiyi belirlemektir.

**GEREÇ VE YÖNTEM:** Düşme sonrası ekstremite kırığı nedeniyle acil ile ortopedi ve travmatoloji polikliniğine başvuran 30 çocuk hasta çalışmaya alındı. Kırık tedavisi sonrası hastalar taburculuk öncesi veya taburculuk sonrası ilk poliklinik takibinde göz bulguları açısından değerlendirildi. Göz hastalıkları polikliniğine rutin muayene için başvuran yaş ve cinsiyet uyumlu, sağlıklı 30 çocuk da kontrol grubu olarak alındı. Tüm katılımcılara sikloplejik refraksiyon, görme keskinliği seviyeleri ve yakın stereopsis ölçümü dahil olmak üzere kapsamlı bir oftalmolojik muayene yapıldı.

**BULGULAR:** Her iki grupta da erkek katılımcı sayısı daha fazlaydı. Gruplar arasında yaş ve cinsiyet dağılımı açısından anlamlı fark yoktu. En sık üst ekstremite kırıklarının distal radius (%52) ve distal humerus kırıkları (%28) olduğu görüldü. Gözlük gerektiren kırma kusuru olan hasta sayısı kırık grubunda anlamlı olarak daha yüksekti ( $p=0.039$ ). Daha iyi olan gözün görme keskinlikleri değerlendirildiğinde, kırık grubunda ortalama görme keskinliği anlamlı olarak daha düşüktü ( $p=0.016$ ). Ortalama stereopsis de çalışma grubunda önemli ölçüde daha düşüktü ( $<0.001$ ). İkili lojistik regresyon analizi modelinde, düşük stereopsis seviyelerinin, pediatrik ekstremite kırığı riski ile ilişkili olduğu bulundu (%95 GA: 1.056–1.385;  $p=0.006$ ).

**TARTIŞMA:** Çalışmamız, düşük enerjili pediatrik ekstremite kırıklarının tedavi gerektiren görme bozukluğu olan çocuklarda daha sık olduğunu ve düşük stereopsisin kırık için risk faktörü olduğunu göstermiştir. Sonuç olarak, çocuklarda düzenli göz muayeneleri ve görme bozukluklarının erken tedavisi, düşmeye bağlı yaralanmaların önlenmesine yardımcı olabilir.

**Anahtar sözcükler:** Çocukluk çağı; ekstremite kırığı; görme bozukluğu; stereopsis.

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