Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/xq3dfa33

POSITIVE PREDICTIVE VALUE OF RADIOLOGICAL KNEE EFFUSION SIZE IN TRAUMATIC KNEE INJURY IN PREDICTING INTERNAL DERANGEMENT TAKING MAGNETIC RESONANCE IMAGING AS GOLD STANDARD".

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ABSTRACT

Objective: This study sought to investigate whether the size of knee effusion visible on X-rays can effectively predict internal knee injuries in children with trauma, using MRI as the reference standard for diagnosis.

Methods: A cross-sectional study was performed at the Department of Diagnostic Radiology in Children's Hospital Lahore from October 29, 2019, to April 28, 2020. The sample included 101 children, aged 4 to 12 years, of both genders, who presented after knee trauma with suspected internal knee injuries indicated by knee effusion (≥1 cm in anteroposterior diameter on lateral X-ray). The diagnosis was confirmed through MRI, which served as the gold standard. Each X-ray was evaluated for knee effusion, categorizing the findings as true positive or false positive. Informed consent was obtained from the parents of all participating children.

Results: The average age of the participants was 8.6 years, with a standard deviation of 2.4 years. Among the participants, 73 (72.3%) were boys and 28 (27.7%) were girls, resulting in a male-to-female ratio of 2.6:1. Internal knee injuries were confirmed in 93 children (92.1%) via MRI. The study revealed a positive predictive value of 92.1% for knee effusion detected on X-rays in predicting internal knee injuries, a value that was consistent across various subgroups based on age, gender, and weight.

Conclusion: The findings indicate that knee effusion size on X-rays holds a high positive predictive value (92.1%) for identifying internal knee injuries in pediatric trauma cases, as confirmed by MRI. The advantages of X-rays—being quick, non-invasive, cost-effective, and widely available—support their use in assessing children with knee injuries in clinical practice.

Keywords: Knee trauma, Internal knee injuries, Knee effusion, Positive predictive value, Pediatric trauma, MRI

INTRODUCTION

The knee is a complex joint characterized by its remarkable mobility and stability, attributed to its unique structure of bones and ligaments. In the emergency department (ED), post-traumatic knee pain is a frequent complaint. Plain radiographs serve as an essential tool for clinical decision-making, enabling healthcare providers to rule out knee fractures effectively, thereby minimizing unnecessary costs and reducing radiation exposure (1). When there is a suspicion of ligamentous or meniscal injury, it is important for the ED physician to facilitate prompt follow-up with either the patient's primary care physician or an orthopedic specialist, who can then evaluate the need for MRI and further treatment. Patients who experience high-energy impacts may be at increased risk for hidden fractures and vascular injuries [2, 3, 4].

Knee trauma can arise from various conditions, including bone bruises, fractures, and soft tissue injuries, such as damage to the menisci, cruciate ligaments, collateral ligaments, and surrounding muscles (5). For general practitioners, diagnosing knee injuries beyond fractures or locked knees can be particularly challenging. Moreover, patients with femoral fractures often present with simultaneous knee injuries, which can easily be overlooked during initial assessment, as the focus is usually directed toward the primary injury [6, 7, 8].The accuracy of MRI in detecting knee injuries is considered perfect, demonstrating both 100% sensitivity and specificity.9,10. In their research, Cecava et al. found that the positive predictive value (PPV) for identifying effusion in traumatic knee injuries through x-ray was 93.0%.

This version keeps the key points while rephrasing the content. Make sure to also properly cite the studies and sources in your bibliography.[11] The PPV is influenced by the prevalence of the condition, and to the best of the candidate's knowledge, no local published data on this topic is available. On the other hand, internal ligamentous or meniscal injuries if left untreated have a catastrophic effect with loss of normal architecture of the joint leading to injury to the other parts of the joint ultimately causing the joint destruction[12]. This study determined the PPV of effusion size on the radiographs to predict the internal injuries of the knee joint in pediatric trauma, a relatively cheap and easily accessible investigation that can help in reducing the morbidity associated with the missed internal injuries of the knee joint.

METHODOLOGY:

This cross-sectional research was carried out at the Department of Diagnostic Radiology, Children's Hospital Lahore, from October 29, 2019, to April 28, 2020. A total of 101 cases were selected, calculated based on a 95% confidence interval and a 5% margin of error, with the anticipated positive predictive value (PPV) of effusion size on x-ray in predicting internal knee joint injuries in pediatric traumatic knee cases estimated to be 93%.[11] Patients were chosen using non-probability consecutive sampling methods.

After receiving approval from the hospital's ethical review committee, participants who met the inclusion criteria were enrolled consecutively until the required sample size was reached, with written consent obtained from the parents of each child. Patients with knee bone fractures, a history of knee surgery, or dislocated knee joints as determined through clinical examination were excluded from the study. A digital cross-table lateral x-ray of the knee joint was performed, and internal injuries were classified based on effusion size according to the operational definition. MRI was carried out in the supine position using a 3.0 T scanner, following standard knee protocols, which included sagittal T1, coronal proton density, and triplane proton density fat saturation sequences. Internal injuries detected on MRI were classified according to the operational definition. All patient data were thoroughly recorded in the provided proforma, which also included demographic information. Both MRI and x-ray examinations were conducted using the same equipment and interpreted by the same radiology consultant to reduce bias, while confounding variables were

controlled using the exclusion criteria. The gathered data were analyzed with SPSS version 21.0. Numerical data, such as age and weight, were expressed as mean ± standard deviation (SD), while categorical data, including gender and MRI-confirmed knee injuries, were reported as frequency and percentage. The positive predictive value (PPV) of knee effusion was calculated using the designated formula and presented as frequency and percentage. Data were further analyzed by age, gender, and weight to adjust for potential effect modifiers. After stratification, the chi-square test was applied, with a significance level of $p \leq 0.05$, and the PPV was recalculated.

$$PPV = \frac{\text{True positive}}{\text{True positive + false positive}}$$

RESULTS

The age of the children in the study ranged from 4 to 12 years, with a mean age of 8.6 ± 2.4 years. The majority of participants (n=64, 63.4%) were aged 8 years or older. Among the participants, there were 73 boys (72.3%) and 28 girls (27.7%), resulting in a male-to-female ratio of 2.6:1. The weight of the children varied from 16 kg to 48 kg, with a mean weight of 32.9 ± 8.4 kg, as shown in Table 1. A total of 93 children (92.1%) exhibited internal knee injuries confirmed by MRI, as shown in Table 2. This resulted in 93 true positive cases and 8 false positive cases, leading to a positive predictive value of 92.1% for radiographic knee effusion in detecting internal knee injuries, with MRI serving as the gold standard, as detailed in Table 2. Similar positive predictive values were observed in different subgroups of children based on age, gender, and weight, as illustrated in Tables 3 to 5.

Table 1: Demographic characteristics of the children included in the study.

Characteristics	**Participants n=101**
Age (years)	8.6±2.4
• <8 years	37 (36.6%)
• ≥8 years	64 (63.4%)
Gender	
• Boys	73 (72.3%)
• Girls	28 (27.7%)
Weight (Kg)	32.9±8.4
• <30 Kg	32 (31.7%)
• ≥30 Kg	69 (68.3%)

Table 2 Frequency of internal injuries of knee on MRI and positive predictive value of knee effusion on X-ray n=101

MRI Diagnosis	**Frequency (n)**	**Percent (%)**
Internal Injuries of Knee (True Positive)	93	92.1%
No (False Positive)	8	7.9%
Total	101	100.0%

Positive Predictive Value = 93 x 100
93 + 8
Positive Predictive Value = 92.1%

Table 3 Positive Predictive value of radiographic knee effusion across age

Age	Diagnosis on MRI				
	True Positive (n=93)	False Positive (n=8)	Total	PPV	P-value
<8 years (n=37)	34 91.9%	3 8.1%	37 100.0%	91.9%	0.958
≥8 years (n=64)	59 92.2%	5 7.8%	64 100.0%	92.2%	
Total	93 92.1%	8 7.9%	101 100.0%		

Using the Chi-square test, the observed difference was found to be statistically insignificant. PPV stands for positive predictive value.

Table 4 Positive predictive value of radiographic knee effusion across gender

Gender	Diagnosis on MRI				
	True Positive (n=93)	False Positive (n=8)	Total	PPV	P-value
Boys (n=73)	67 91.8%	6 8.2%	73 100.0%	91.8%	0.858
Girls (n=28)	26 92.9%	2 7.1%	28 100.0%	92.9%	
Total	93 92.1%	8 7.9%	101 100.0%		

The Chi-square test indicated that the difference observed was not statistically significant. PPV stands for the positive predictive value.

Table 5 Positive predictive value of radiographic knee effusion across weight

Weight	Diagnosis on MRI				
	True Positive (n=93)	False Positive (n=8)	Total	PPV	P-value
<30 Kg (n=32)	30 93.8%	2 6.2%	32 100.0%	93.8%	0.672
≥30 Kg (n=69)	63 91.3%	6 8.7%	69 100.0%	91.3%	
Total	93 92.1%	8 7.9%	101 100.0%		

The Chi-square test indicated that the observed difference was statistically insignificant. PPV stands for positive predictive value.

DISCUSSION:

In recent decades, there has been a significant global reduction in child mortality due to ongoing and sustained efforts aimed primarily at addressing communicable diseases[13]. However, it has become increasingly clear that children who survive these diseases are often victims of trauma in various environments, such as on the roads, in play areas, or at home. Pediatric injuries are now a leading cause of mortality and disability worldwide, placing a considerable burden on resource-limited countries (2). While knee injuries are common, lower limb injuries, particularly those below the

knee, may not be life-threatening; nonetheless, they can result in substantial functional disabilities with long-lasting physical and psychosocial consequences [6, 14].

Internal knee injuries are frequently overlooked following trauma, especially when no obvious fracture is present, leading to delayed presentation when significant and potentially irreversible degenerative changes have occurred. Although MRI is the gold standard for diagnosing soft tissue injuries of the knee, its use is often limited by constraints related to time, availability, and cost[7, 15].

The synovial membrane is crucial for the dynamics and pathology of the knee joint. Composed of thin connective tissue, the synovium secretes synovial fluid, which lubricates and nourishes the joint while removing intra-articular debris. The initial sign of synovial disease is often joint effusion, which can result from trauma, overuse, or systemic disease [2, 3, 10]. Minimal joint effusion is sometimes overlooked [16,17], but larger effusions raise concerns and necessitate further investigation[3].

A recent study suggested that the size of knee effusion visible on plain X-ray could reliably predict internal knee injuries, potentially limiting the need for MRI in select cases[11]. However, existing evidence regarding the positive predictive value of radiographic knee effusion for diagnosing internal knee injuries is limited, and no locally published data exists, highlighting the need for the present study.

The objective of this study was to assess the positive predictive value of knee effusion size on X-rays in pediatric trauma cases, using MRI as the gold standard. The average age of the children in our study was 8.6 ± 2.4 years, with 63.4% of the participants aged 8 years or older. The sample consisted of 73 boys (72.3%) and 28 girls (27.7%), resulting in a male-to-female ratio of 2.6:1. A similar pattern was observed in a study by Bhatti et al. (2018) at Jinnah Postgraduate Medical Centre Karachi, which also found a male predominance with a male-to-female ratio of 2:1.18 This finding is consistent with an Indian study by Parmeswaran et al. (2017), where the mean age was 8.5 ± 5.1 years, and the male-to-female ratio was 1.5:1.19 Additionally, another study by Kundal et al. (2017) reported a comparable male predominance. (M:F; 2.8:1) [20]. The higher proportion of children aged 8 years and older, along with the male predominance, correlates with mechanisms of injury, particularly road traffic accidents, which often involve older boys who can ride bicycles or drive motorbikes. We found the positive predictive value of radiographic knee effusion to be 92.1% in predicting internal knee injuries in pediatric trauma, taking MRI as the gold standard. This positive predictive value was consistent across various subgroups of children based on age, gender, and weight. Our findings are consistent with a previous study by Cecava et al. (2018), which evaluated the results of radiographic knee effusion in 198 patients and reported a similar positive predictive value of 93.0% using a cutoff value of ≥1 cm[11].

This study is the first of its kind conducted within the local population and adds to the limited international research available on this subject. The positive predictive value of radiographic knee effusion was determined to be 92.1% for predicting internal knee injuries, irrespective of the patient's age, gender, or body weight. Compared to MRI, plain X-ray is relatively inexpensive and widely available in tehsil and district hospitals. It is also a quicker diagnostic tool, with films available for evaluation sooner, thus saving valuable time in managing such injuries. Based on this evidence, we advocate for the routine use of radiographic knee effusion in evaluating children with knee trauma in future practice.

The strengths of this study include a substantial sample size of 101 cases and the application of stringent exclusion criteria. Additionally, we stratified the results based on potential effect modifiers such as age, gender, and weight. However, a significant limitation of this study is that it only included cases with suspected internal knee injuries based on radiographic knee effusion, which prevented the evaluation of negative cases. Including these cases would have enabled the calculation of negative predictive value and overall diagnostic accuracy, offering a more comprehensive understanding of the role of radiographic knee effusion in assessing these children. Future clinical research should focus on addressing this gap.

CONCLUSION

The positive predictive value of knee effusion on X-ray was found to be 92.1% in predicting internal injuries of knee in taking MRI as gold standard regardless of patient's age, gender and body weight. Furthermore, its quick, non-invasive nature, low cost, widespread and bedside availability advocates its preferred use in the evaluation of children presenting with knee trauma in future practice.

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