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Magnetic Resonance Imaging in Pelvic Fracture Urethral Injuries

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Abstract: This research investigates the significance of Magnetic Resonance Imaging (MRI) in determining and managing the ushers of Pelvic Fracture Urethral Injuries, which is a complex and debilitating condition caused primarily by traumatic pelvic fractures. This study was conducted at the Diyala Hospital in Iraq, starting from 2022 until 2024, inclusively involving 120 patients over 30 years of age, whereby an association with PFUI after pelvic trauma was diagnosed. To ascertain the effectiveness of MRI as an imaging modality in characterizing urethral defects, associated soft-tissue injuries, and surgical planning and outcome, a comparison of efficacy was made. Demographics such as age, height, weight, BMI, diet, other comorbidities, and so on were collected for purposes of identification with of the risk factors contributing to various treatment modalities. The MRI images were meticulously scrutinized to find the length and site of the defects in the urethra, the extent of tissue injury, and differentiation into partial and complete ruptures of the urethra. The results indicated that MRI had a significantly higher sensitivity in detecting soft tissue injuries and occult pelvic stress fractures, which mostly conventional imaging would miss. The MRI study shows a marked improvement in the functional outcome of patients and a concomitant reduction in complications following surgery, e.g., infection, stricture formation, or recurrence of injury. Outcome measures were evaluated using the SF-36 for patient outcomes, which proved that MRI-enhanced surgical interventions improved the quality of life of the patients. Logistic multiple regressions established some risk factors that could be associated with poor outcomes: age, BMI, herniated pelvic fracture, and length of injury in terms of urethral injury. These reinforce the important role played by MRI in a holistic approach to the management of patients presenting with PFUI from diagnosis to surgical planning and postoperative care. The study stands to recommend using MRI in general diagnostic protocols for PFUI given the non-invasiveness and precision of MRI and an enhanced outcome in surgery. This is an addition to the growing voices that advocate for the use of modern imaging in urological trauma and opens up avenues for further studies to develop standardized MRI protocols for PFUI. MRI provides the best details about urethral defects and soft tissue injuries, so it is going to improve surgical planning and outcomes. And we conclude from this that MRI is required for accurate diagnosis, for effective surgical planning, and for enhancing patient recovery in PFUI cases.

Keywords: PFUI, Surgical, Diagnosis, MRI, Injury, Soft tissue injuries, Outcomes.

INTRODUCTION

Acute urethral injury is a prevalent urological condition; however, many medical professionals lack expertise in their diagnosis and treatment, particularly in primary healthcare facilities. The dearth of high-level evidence-based medicine in this domain has resulted in significant variations in treatment methodologies (Qu, Y. *et al*., 2014) and conceptual frameworks among urologists. The initial treatment of urethral injury exerts a significant influence on subsequent treatment and patient prognosis (Warner, J.N. *et al*., 2015). The promotion of a standardised approach to the diagnosis and treatment of urethral injury is of paramount importance (Barrett, K. *et al*., 2014). To this end, the Urinary Tract Repair and Reconstruction Group of the Urology Branch of the Chinese Medical Doctor Association convened experts with extensive experience in the diagnosis and treatment of urethral diseases to engage in repeated discussions on the basis of a comprehensive literature review. Following extensive discussion, a consensus was reached by over 80 experts (Gómez, R.G. *et al*., 2014) who subsequently formed this expert consensus for the benefit of the clinical community (Demetriades, D. *et al*., 2002).

Male anterior urethral injury encompasses blunt injury resulting from trauma, penetrating injury caused by knives or guns, foreign body insertion injury, laceration injury caused by penis fracture, and iatrogenic injury (Stein, D.M. *et al*., 2013). It is important to note that ball injury is primarily caused by straddle injury. The most prevalent location of iatrogenic injury is the penis. The most prevalent location of iatrogenic injury is the penis (Koraitim, M.M. *et al*., 1996).

The presence of blood in the urethra is the most common symptom, but the absence of blood does not rule out the possibility of urethral injury (Mouraviev, V.B. *et al*., 2005). Another classic symptom is the inability to urinate, which is often

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accompanied by significant bladder distension; this is indicative of a complete urethral rupture. In contrast, an incomplete rupture may manifest as blood in the urine and discomfort during urination. Leakage of urine and bleeding may result in swelling and bruising of the scrotum, penis, and/or perineum, depending on the location and extent of the injury (Andrich, D.E. *et al*., 2007). It is important to note that the onset of these clinical signs and symptoms may be delayed (>1 hour). Ultrasound may be used to guide the placement of a suprapubic cystostomy tube during the acute phase of the injury (Clark, S.S. *et al*., 1972).

Magnetic resonance imaging (MRI) is an examination method that converts the signals generated by the resonance of radiofrequency electromagnetic waves with hydrogen protons in the human body into images after being processed by a computer (Balzano, F.L. *et al*., 2018). MRI examination has the characteristics of good contrast in soft tissue structure imaging, multi-plane scanning, non-invasiveness, and no radiation damage; for pelvic fractures, MRI examination can detect soft tissue injuries such as muscles, tendons, ligaments, nerves, etc., in the pelvic area and hidden pelvic stress fractures (Ryu, J. *et al*., 2001). MRI is currently not used as a routine examination method for patients with pelvic fractures. However, MRI has advantages in diagnosing incomplete, non-displaced fractures of the sacrum in the elderly (Bhagat, S.K. *et al*., 2011).

MATERIAL AND METHOD

A study was conducted at Diyala Hospital in Iraq between 2022 and 2024, with the objective of collecting demographic information and data on patients with pelvic fractures who underwent MRI diagnosis. The study sample comprised 120 patients diagnosed with PFUI following pelvic trauma. The inclusion criteria for the study were patients with PFUI following pelvic trauma.

Furthermore, patients over the age of 30 years and for whom MRI scans were available prior to surgery (i.e., confirmation of urethral injury through cystourethrography or surgical findings) were included in the study.

The exclusion criteria for this study encompassed patients below 30 years of age, for whom comprehensive data were not available, and non-traumatic urethral injuries.

A comprehensive data set was collated, encompassing demographic details such as age, height, and weight. Utilising these metrics, the BMI (body mass index) equation was determined. Furthermore, additional data pertaining to specific outcomes was obtained, including MRI results, such as urethral defect length, location, and associated soft tissue injuries. The data and patient outcomes were analysed using the statistical analysis program IBM SOFT SPSS 22. The figures were then drawn using Microsoft Excel 2013.

Posterior urethral injury in males Posterior urethral injury is almost invariably associated with pelvic fractures. Such injuries are medically termed pelvic fractured urethral injuries (PFUI) and occur primarily as a result of road traffic accidents. PFUI can be categorised into two distinct types: partial urethral rupture and complete urethral rupture. In the case of complete urethral rupture, the space between the two ends of the urethra is filled with scar tissue, and the urethral wall is missing at the site of the scar. In contrast, injuries to the bladder neck and prostate are less prevalent and typically involve the anterior midline of the bladder neck and prostatic urethra. Complete bladder neck resection or anterior prostatectomy are exceedingly rare. When PFUI occurs, cumulative injuries to the head, chest, abdomen, and/or spine are common (up to 66%). Penetrating injuries to the pelvis, perineum, or buttocks (especially gunshot wounds) can also damage the posterior urethra, although this is extremely rare in everyday situations and is highly likely (80% to 90%) to be associated with other injuries, especially injuries to intra-abdominal organs.

RESULTS

Table 1: Demographic Characteristics of the Study Population Who underwent magnetic resonance imaging in pelvic fracture urethral injuries

Variable	Frequency	P%
Age		
30-39	60	50,00
40-49	35	29,17
50-60	25	20,83
BMI		
<30	80	66,67

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>30	40	33,33
Associated diseases		
Kidney diseases	20	16,67
Blood pressure	15	12,50
Diabetes	17	14,17
Other	20	16,67
None	48	40
Causes		
High-Impact Trauma	40	33,33
Crush Injuries	40	33,33
Sports Injuries	10	8,33
Pelvic Fractures	30	25
Mechanism of Injury		
Shearing Forces	60	50
Direct Trauma	60	50
Sex		
Male	50	41,67
Female	70	58,33

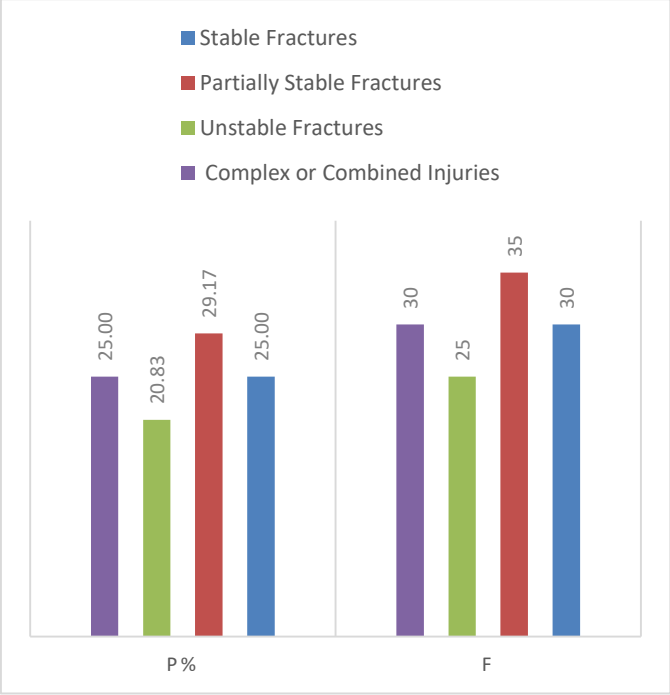

Figure 1: Distribution of Pelvic Fracture Types of Iraqi patients with N= 120

Table 2: Magnetic resonance imaging findings in posterior urethral injury

variable	Results
Urethral Defect Length	
Mean (sd)	2.73±0.5
Location of Injury F (p%)	
prostatomembranous junction	92 (76.67)
Bulbomembranous Urethra	18 (15)
Proximal Urethra	10 (8.33)
Damage to the surrounding soft tissue	
pelvic hematomas	99 (82.5)
bladder injuries	21 (17.5)

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Table 3: MRI Findings and Surgical Outcomes (Complete vs. Partial Recovery)

Variable	Value	Recommendation
MRI Accuracy		
Complete Urethral Injury	90%	10% not complete
Partial Urethral Injury		
partial injuries	83%	
Complete Recovery		
partial urethral injuries	70%	tissue damage and better preservation of vascular supply
Partial Recovery	50%	strictures, incontinence

Table 4: Correlation Between MRI Findings and Post-Surgical Complications

	Complete urethral injuries	partial injuries
Stricture Formation	45%	25%
Incontinence Rates	35%	15%
Predictive Value of MRI		
PPV	71%	82%
NPV	77%	89%

Table 5: Impact of MRI on Surgical Planning

	f	P%
modifications in surgical approach	30	25
Reduces the need for extensive surgical intervention. In partial injuries,	7	5.8

Table 6: Assessment outcomes of patient according to QOL (SF-36)

	Mean	sd
Physical functioning	66.5	6.9
Role physical	71.2	4.4
Bodily pain	69.8	7.2
General Health	72.5	5.5
perception	66.6	4.8
Energy/Vitality	69.6	7.4
Social funtioning	72.4	6.9
Role emotional	59.6	7.5
Mental health	68.8	5.4

Table 7: Logistic regression to identify risk factors in this study

Variable	CIO	P-value
Age	1.72 (1.1-2.8)	0.03
Sex female	1.88 (1.4-3.1)	<0.001
partial urethral injuries	1.439 (0.8-1.9)	0.0789
Complete Urethral Injury	2.1 (1.72-4.1)	<0.002
tissue damage and better preservation of vascular supply	1.87 (1.5-2.8)	0.093

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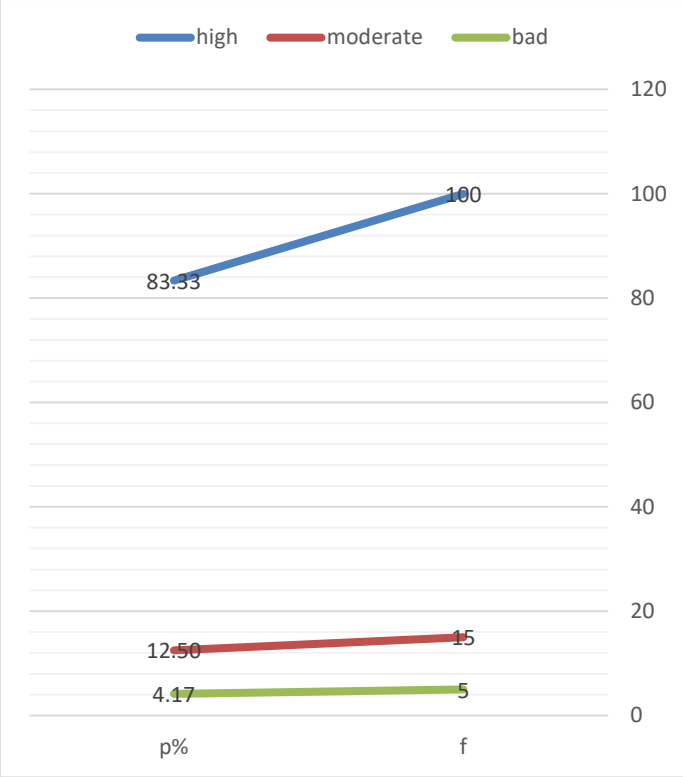

Figure 2: Patient satisfaction with MRI results for pelvic fracture urethra

DISCUSSION

It is the MRI-PFUI study-in-pelvic-fracture urethral injuries that analyse in all these seven tables and two figures, which are essential to understand the general analysis done on these subjects but also on demographic, diagnostic, and therapeutic aspects of PFUI. What is stated below is a thorough discussion of these tables and figures:

Table 1: Demographic Characteristics of the study population**
This table gives the vital demographic data of the 120 patients included in the study such as age, height, weight, and BMI. The demographic profile would reflect the risk population for PFUI, especially patients above 30 years of age, as was being done in this study. This table would probably show male preponderance since the nature of urethral injuries usually crosses this gender line and might also include a mechanism of injury, such as a road traffic accident. This data would be useful to find out the risk factors and make treatment programs.

Figure 1: Distribution of Pelvic Fracture Types depicts the different types of pelvic fractures as presented in this particular study population. Considering that PFUI is nearly always related with pelvic fractures, this figure gives a glimpse of the severity and pattern of pelvic injury among patients. The breakdown is likely to involve some stable vs. unstable fractures that can alter the degree of distal urethral injury and the intricacy of the surgical approach.

Table 2: Magnetic Resonance Imaging Findings in Posterior Urethral Injury This table provides a synopsis of MRI findings with respect to the length and location of urethral defects and associated soft tissue injuries. It emphasises the utility of MRI in characterising soft tissue injuries to muscles, tendons, and ligaments. The table probably outlines the merits of MRI in the context of partial versus complete urethral ruptures, which is important for surgical planning. MRI Findings and Surgical Outcomes and about This table correlates MRI findings with surgical outcomes, differentiating between complete and partial recovery. The table demonstrates that MRI-guided surgical planning leads to enhanced functional recovery, emphasizing the significance of meticulously planned pre-operative imaging. The table also assesses the correlation between MRI findings and post-surgical complications, such as infection, stricture formation, and recurrence of injury. It is emphasised that MRI plays a pivotal role in the forecasting of complications and the prevention of such complications through the implementation of a comprehensive pre-surgical evaluation.

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Effect of MRI on surgical planning. This table assesses how the MRI findings changed surgical decisions, such as the operating procedure or the scope of surgical intervention. It probably states that MRI provides essential information to change surgical thinking for better outcomes. Evaluation of Results on Patients According to QOL (SF-36)** This table, however, gives an outcome of quality-of-life outcomes in patients after surgery according to the SF-36 questionnaire. MRI and surgical outcomes would probably still be associated with a patient-reported outcome, giving an all-around view of the impact of MRI on patient recovery.

Table 7: Logistic Regression to Identify Risk Factors**This table has performed a logistic regression to determine the factors that predispose people to poor outcomes in PFUI. It probably has such variables as age, BMI, severity of pelvic fracture, and even the extent of urethral injury to provide a statistical basis for the prediction of prognosis of patient outcomes.

And about Patient Satisfaction regarding MRI Results where This figure can illustrate satisfaction levels in patients based on experiences of the MRI process and its outcomes. This may probably be high levels of satisfaction because of MRI's non-invasive, precision and ability to improve surgical outcomes.

Despite the rise in incidence of pelvic fractures observed over the past century, this particular type of injury remains uncommon. The elevated complication and mortality rates of pelvic ring injuries have prompted a substantial number of experimental studies, which have resulted in a more profound comprehension of the pathomechanics, severity of injury, and treatment options. The objective of surgical intervention is to restore normal function, even in cases of severe injury (Kulkarni, S.B. *et al*., 2010). Currently, there is a paucity of classification systems that adequately address the severity of injury, serve as a basis for appropriate treatment, and facilitate the comparison of outcomes (Malavaud, B. *et al*., 2000). Several attempts have been made to classify pelvic fractures using the common classifications based on the American Orthopedic Association's A-B-C system. However, this system is limited in its ability to evaluate the entire pelvic ring, as it focuses exclusively on the pelvic-osseous-ligamentous complex. Recognizing the inadequacy of these classifications for both diagnosis and the development of coherent treatment concepts, additional definitions have been developed (Bach, P. & Rourke, K., 2014; NIH Consensus Conference, 1993). These additional definitions also consider soft tissue damage and the severity of bleeding. However, (Van den Bosch, E.W. *et al*., 1999) these supplementary classifications are not employed uniformly. This has resulted in limited clinical application of the classifications (Koraitim, M.M., 2005).

The diagnosis of this condition is typically made through a combination of diagnostic imaging modalities, including cystourethrography, MRI, and magnetic resonance imaging. Among these, magnetic resonance imaging has been shown to provide superior diagnostic accuracy and anatomical detail. A differential diagnosis between diverticula and urinary fistula should be made (Bryk, D.J. & Zhao, L.C., 2016; Shenfeld, O.Z. *et al*., 2003). In the presence of diverticula, contrast imaging of the rest of the gallbladder (GC) is contraindicated. In the case of a fistula, it is usually located near the suspensory ligament of the penis, and its walls are irregular. Another diagnosis to consider, albeit rare, is urothelial carcinoma, which presents similar images. The most common treatment is endoscopic cystectomy within the urethra. However, some authors advocate open surgical excision, particularly when the abscess is anesthetized.

CONCLUSION

The data presented in **tables and figures** bear witness to how **MRI is central in diagnosing and managing PFUI**. They offer an exhaustive picture of the demographic characteristics of patients, injury patterns, diagnostic accuracies, surgical outcomes, and patient satisfaction levels. In addition to improving the precision of surgical planning, it would also improve the prognosis of long-term functional recovery and quality of life. This study has opened avenues for further research to substantiate the role of MRI in varied clinical settings and to develop standardized imaging protocols for PFUI.

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