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Application of Hypothetico-Deductive Reasoning Process for Physiotherapy Management of a Case with Meniscus Injury

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ABSTRACT

Background: Clinical reasoning refers to the professional decision-making involved in physical rehabilitation. The hypothetico-deductive reasoning (HDR) model integrates clinicians' self-perceptions with structured clinical decision-making processes. This study aimed to evaluate the application of the HDR process in the physiotherapy management of a patient with a meniscus injury.

Methods: The case involved a 42-year-old male banker referred for physiotherapy rehabilitation, presenting with severe pain, swelling, catching, and locking of the right knee joint. This single-case study was addressed using the HDR process.

Results: By the eighth week of intervention, improvements were observed in pain reduction, muscle strength, and range of motion of the knee joint. Additionally, the meniscus evaluation score improved from 20.9% to 71.4%. The subject is now able to participate in routine daily activities. Clinical reasoning, central to practice, was critical in this atypical presentation of a meniscus tear; thus, the HDR process was employed for diagnosis and problem-solving.

Conclusion: The HDR process offers a holistic treatment framework and can be effectively applied to unfamiliar or atypical clinical conditions such as meniscus injuries.

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Introduction

Clinical reasoning (CR) refers to healthcare professionals' internal thinking and decision-making processes, conducted systematically and professionally [1]. Healthcare professionals, particularly therapists, can address clinical challenges diligently and proficiently by employing various clinical reasoning strategies [2]. CR is a complex phenomenon, encompassing both cognitive and interactive components. It often operates automatically and subconsciously, making it difficult to observe directly. It is also multifactorial and task-oriented in nature [3]. Broadly, CR is defined as the thought processes and decision-making procedures underlying professional judgment.

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Ultimately, decision-making can be considered an integral part of the CR process [4].

Hypothetico-deductive reasoning (HDR) involves self-perceptions and a structured clinical decision-making process in which hypotheses are generated and tested based on the patient's presenting clinical features [5]. This process consists of four fundamental steps: cue acquisition, hypothesis formation, cue interpretation, and hypothesis evaluation. Cue acquisition involves identifying and collecting relevant clinical data specific to the case [6]. In the early stages of patient care, expert clinicians typically generate a few tentative hypotheses to guide further evaluation [7]. The HDR model is instrumental in diagnosing rare, unfamiliar, or complex conditions requiring high diagnostic precision. It is often employed by novice practitioners in cases involving soft tissue injuries and musculoskeletal conditions, supporting the implementation of appropriate therapeutic interventions.

The meniscus is one of the most commonly injured structures of the knee joint. Meniscal injuries frequently occur in young individuals following a twisting knee injury, resulting in severe pain, swelling, catching, clicking, and possibly locking during knee flexion [8]. Standard clinical features of a meniscal tear include popping, catching, locking, buckling, mild synovitis, and joint line pain [9]. Clinical reasoning is a fundamental component of physiotherapy practice, playing a crucial role in the diagnostic and intervention processes for patients [10]. Physical exercise therapy should be considered a viable alternative to surgical intervention in managing meniscal injuries [11]. This study aimed to evaluate the application of the hypothetico-deductive reasoning process in the physiotherapy management of a patient with a meniscus injury.

Methods

Participant

The participant was a 42-year-old male banker with a history of a traumatic knee injury sustained two months before physiotherapy referral. At the time of the injury, the right knee was flexed and subjected to a twisting motion. He experienced severe joint line pain and noticeable swelling of the right knee. The intensity of the pain prevented him from bearing weight or placing the foot on the ground. His symptoms worsened upon attempting to bear weight on the affected knee. Immediately after the injury, he consulted a general physician and was later evaluated by an orthopedic specialist, who prescribed medical management and advised adequate rest. Despite visiting multiple orthopedic centers and receiving prolonged pharmacological treatment, his symptoms initially improved but subsequently worsened and became unresponsive to medication.

The patient presented with severe pain, swelling, catching and clicking sensations, difficulty bending the knee, and locking of the knee in partial flexion. The pain was typically localized to the joint and intensified during torsional and weight-bearing movements, often followed by a dull ache. After several weeks, his condition showed minimal improvement with medical management. Consequently, he was referred to the physiotherapy department at the Centre for the Rehabilitation of the Paralysed (CRP) for comprehensive rehabilitation.

The patient provided informed consent prior to data collection, and all personal information was kept confidential. The Ethics Committee (EC) of the Institute of Physiotherapy, Rehabilitation and Research (IPRR), the academic institute of the Bangladesh Physiotherapy Association (BPA-IPRR/IRB/992/07/2023/651), approved this case study.

Baseline Assessment

Meniscal tears are among the most common knee injuries worldwide [12]. The International Classification of Functioning, Disability, and Health (ICF) model provides a multidimensional framework for assessing and improving quality of life. In this case, impairments in body structure and function were evident, as the patient complained of pain, swelling, reduced joint range of motion (ROM), muscle weakness, and tightness.

The patient reported a dull ache when bearing weight on the affected leg. Upon assessment, activity limitations were identified: he could not fully extend the knee, experienced difficulty with flexion, and presented with knee locking in partial flexion. These impairments hindered his ability to stand, bear weight, and walk effectively. His pain at rest was rated 8 out of 10 on the Visual Analogue Scale (VAS).

Participation restrictions were also noted. The patient was unable to attend family events and social gatherings. Accessibility issues at his workplace, due to inadequate universal design, further contributed to his limitations. Additionally, negative social attitudes and a lack of support exacerbated his functional challenges. These combined factors led to psychological distress, including anxiety, low mood, fear of deformity, and general discomfort regarding his condition.

Manual muscle testing (MMT) revealed a muscle strength grade of 4 for knee flexion and 3+ for knee extension, indicating notable deficits that impacted his ability to perform functional tasks.

Hypothetico-Deductive Reasoning

Due to the complexity of the case and the initial diagnostic uncertainty, the researchers applied the HDR model, utilizing both propositionaland non-propositional knowledge to guide the diagnostic and treatment strategy.

Cue Acquisition

As the first step in the HDR process, the researchers formulated targeted clinical questions to gather essential information and identify relevant cues associated with the patient's condition. The following questions were posed:

- *Is the pain intermittent or constant, and is morning stiffness present?*
  To determine the nature and potential source of pain.
- *Was the injury associated with a traumatic blow or twisting while the knee was bent?*
  To identify the mechanism and pattern of injury.
- *Was the pain sudden or gradual in onset?*
  To help localize the origin of the symptoms.
- *Do you experience pain during weight-bearing?*
  To pinpoint the structure(s) involved.
- *What is the nature of the pain—burning, tingling, dull aching, or electric shock-like?*
  To differentiate between somatic, visceral, or neuropathic origins.
- *Did you hear or feel any sounds like popping or experience locking or giving way of the knee at the time of injury?*
  To assess joint instability or meniscal involvement.
- *Is there swelling or effusion after activity? Is it consistent or recurrent?*
  To evaluate joint inflammation and tissue response.
- *Is there any crepitus during patellar palpation or tenderness at the joint line or along the tibial plateau?*
  To detect local structural abnormalities or inflammation.

Hypothesis Generation

Hypothesis generation was an essential part of the systematic solving of problems. Following cue acquisition and receiving the results, a couple of hypotheses are formed in the clinician's mind:

- There may be an association with patellar tendinitis. Repeated stress on the patellar tendon and pain through the kneecap or tibial shin support this hypothesis.
- Degeneration due to knee osteoarthritis (OA) may have a strong association. Crepitus during patellar palpation and reduced joint range of motion support this hypothesis.
- Patellofemoral pain syndrome may be present. Severe pain under the kneecap was found on palpation, and a crepitus sound in the patella may support this hypothesis.
- A meniscus injury is likely. Trauma with twisting knee bending, a popping sound during the injury, locking of the knee during walking, and recurrent joint effusion support this hypothesis.
- Medial collateral ligament (MCL) injury may be another cause. Severe pain and joint laxity support this hypothesis.
- There may be an association with anterior cruciate ligament (ACL) injuries. Joint effusion, severe pain, and joint laxity support this hypothesis.

Cue Interpretation

A three-point scale was used for cue interpretation, where a '+1' cue confirms the hypothesis, a '-1' disconfirms the hypothesis, and a '0' cue does not contribute to the hypothesis [7]. The cue interpretations are given below:

1. There is no history of repeated stress on the patellar tendon and no pain between the kneecap and the tibial shin. Therefore, the hypothesis of patellar tendinitis is disconfirmed (-1).
2. In radiographic findings, the joint space was normal, cartilage was in good shape, the tibial spine was not spiky, and no crepitus sounds were found during patellar palpation. Thus, the degeneration of the OA knee hypothesis does not contribute to the symptoms (0).
3. The patellar compression test was not positive. On palpation, there was no severe pain under the kneecap or crepitus sound in the patella. Therefore, the hypothesis of patellofemoral pain syndrome is disconfirmed (-1).
4. There was trauma with twisting knee bending and a popping sound during the injury. Pain, particularly in the joint line, worsened with knee straightening. A recurrent joint effusion with a small volume was observed. McMurray and Apley's tests were positive. These cues strongly confirm the hypothesis of a meniscus injury (+1).
5. The valgus stress test was not positive, and no joint laxity was present. Therefore, the hypothesis of MCL injury is disconfirmed (-1).

6. The Anterior Drawer test and Lachman test were negative. Also, no joint laxity was present. Thus, the hypothesis of ACL injury disconfirms (-1).

Hypothesis Evaluation

The final stage of HDR was hypothesis evaluation. Researchers weighed the advantages and disadvantages of each possible explanation for the patient's signs and symptoms and chose the favored one based on the evidence. After completing all analyses, researchers concluded that the evidence supports Hypothesis IV. McMurray and Apley's tests are often positive, with specificity values of 98.0% and 99.0% and sensitivity values of 66.0% and 58.0%, respectively [8]. The most useful clinical test for meniscal injury is the Thessaly test, which has a specificity of 98.0% and a sensitivity of 90.0% [13]. The gold standard and initial option for examining probable meniscal rupture is magnetic resonance imaging (MRI), which is most frequently used. Apley's, McMurray's, and joint line tenderness tests are commonly used, while Thessaly's test is a newer dynamic test with high diagnostic accuracy for meniscus injury [14].

Discussion

This case report focused on applying the HDR process to diagnose and manage a patient with a meniscus injury through physiotherapy. A comprehensive evaluation is essential for the decision-making process to ensure an accurate diagnosis and effective management. This case contributes to global research knowledge by providing insight into the correct diagnostic process and physical rehabilitation of meniscus injuries.

Researchers used several outcome measurement tools, including the VAS, to assess pain intensity. After eight weeks of intervention, improvements were observed in pain reduction, both at rest and during movement. At the post-test evaluation, pain intensity was reported as 2, compared to a baseline score of 8. A goniometer was used to measure joint ROM, and the MMT technique was employed to assess the muscle strength of the knee joint. After eight weeks of intervention, knee flexion increased from 45˚ to 135˚, and knee extension improved from -5˚ to 180˚. Muscle power in knee flexion improved from grade 4- to grade 5, while knee extension improved from grade 3+ to grade 4+.

The evaluation also included the Western Ontario Meniscal Evaluation Tool (WOMET), the first meniscal pathology-specific health-related quality-of-life instrument designed to measure symptoms most relevant to patients with a meniscus tear. The WOMET score improved from 20.9% at baseline to 71.4% after eight weeks of evaluation, indicating substantial progress. The patient is now able to participate in daily activities.

Researchers provided evidence-based physiotherapy treatment for this case. Intensive physiotherapy interventions are highly effective for meniscus injuries in improving ROM, proprioception, and muscle strength. Bae and Kim implemented an 8-week standard exercise program for meniscus injury that included stretching exercises, active facilitatory ROM practices, stationary bicycling, concentric exercises, straight leg raises, and mini squats [15]. For traumatic meniscus injury management, proprioceptive exercises, joint ROM exercises, and muscle strengthening exercises were applied twice weekly for 12 weeks [8]. A physical rehabilitation protocol consisting of three sessions per week, each lasting two hours, over 8 weeks, yielded favorable outcomes in managing meniscus injuries [12].

The HDR procedure is considered superior to other routine interventions for meniscus injury management. It analyzes complex situations like meniscus injuries, identifies injury patterns, and makes constructive decisions. By applying HDR, researchers could evaluate, assess, reach sound conclusions, and ultimately determine the potential outcomes of meniscus injury management. However, a limitation of HDR is its reliance on deductive reasoning to generate hypotheses, which means that consistent errors can lead to mistaken conclusions. The major weakness of HDR is that it poses a trap into which scientists should not fall; clinicians may reach incorrect conclusions due to limitations in their knowledge or the available evidence. Nonetheless, the strength of the HDR process lies in its ability to draw precise and accurate conclusions and support efficient problem-solving. It also provides an opportunity to clarify how concepts and variables are interrelated regarding causes and effects.

Meniscus injury is complex to diagnose but crucial for achieving accuracy. It is often confused with ligament injuries, but HDR helps identify the correct diagnosis, evaluation, and treatment for patients with meniscal injuries. Students and novice practitioners can apply this approach, as it is well-suited to their level of non-propositional knowledge. HDR is a process of constructing a scientific theory focused on explaining results obtained through direct inspection and experimentation. The HDR process involves gathering information from the patient and using it to form a hypothesis, which is then tested. A further hypothesis regarding meniscus injury is developed,

and treatment can then be effectively planned for improved outcomes. Accurate diagnosis, a better treatment plan, and a more effective result can be achieved through HDR procedures. Therefore, the use of HDR makes the treatment protocol design more appropriate than standard procedures.

The results highlighted the importance of policy and clinical practice in decision-making, such as HDR. For novice clinicians and future researchers, this approach will be helpful and essential for identifying problems and confirming diagnoses through the HDR process. During the study, the clinician encountered the challenge of a lack of sufficient articles based on the clinical reasoning process. It would have been beneficial to have published articles correlating with this study. Further research is needed to refine the diagnosis through the decision-making process and provide evidence-based physiotherapy rehabilitation for meniscus injuries, ensuring better patient care.

Conclusion

Clinical reasoning is the cornerstone of clinical practice. As the case was atypical, the researchers utilized the HDR process for diagnosis and problem-solving. The HDR model was chosen to design and implement the therapeutic process, addressing physical, social, and psychological factors. Therefore, it is clear that the HDR process offers a holistic treatment approach for an unfamiliar condition, such as a meniscus injury.

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Authors Contribution

All authors equally contributed to the final version of the study.

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Conflict of interest

The authors declared no conflict of interest.

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