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Research Article

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Multidimensional Pain Assessment in Surgical Interventions of The Knee: ACL Reconstruction and Total Knee Arthroplasty

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Abstract

This study investigated pain levels in patients undergoing anterior cruciate ligament (ACL) reconstruction and total knee arthroplasty (TKA), using a sample of 37 patients divided into two groups. Group G1 consisted of 20 elderly patients (mean age 71.59 years) diagnosed with unilateral knee osteoarthritis who underwent TKA with anesthetic block. Group G2 included 17 adults (mean age 31.62 years) with a complete ACL rupture who underwent ACL reconstruction surgery, also with anesthetic block. Pain was assessed at three time points (pre-surgery, 24 hours post-surgery, and 30 days post-surgery) using the Visual Analog Scale (VAS) and the McGill Pain Questionnaire. The results showed that in Group G1, pain measured by VAS decreased from a mean of 9.76 pre-surgery to 6.16 after 30 days. In Group G2, pain decreased from a mean of 3.76 to 0.71 over the same period. The Number of Words Chosen (NWC) index from the McGill questionnaire was significantly higher in Group G1 compared to Group G2 at all time points, with a statistically significant difference ($p < 0.001$). Additionally, the Pain Rating Index-Affective (PRI-A) was higher in Group G1 (mean of 10.0 pre-surgery) compared to Group G2 (mean of 3.54), showing a significant difference ($p = 0.001$). The study concludes that subjective pain assessments are crucial for guiding therapeutic interventions, particularly in surgical contexts involving anesthetic block.

Keywords: Anterior Cruciate Ligament, Acute Pain, Knee Osteoarthritis, Pain Assessment, Quality of Life

1. Introduction

Knee injuries are a significant concern in both clinical and rehabilitative contexts due to the joint's central role in locomotion, load-bearing, and functional independence. The knee is a complex synovial joint, composed of multiple anatomical structures including bones, ligaments, tendons, cartilage, and menisci, all of which contribute to its stability and biomechanical efficiency. Because of its structural intricacy and functional demands, it is particularly susceptible to injury, which often results in pain, functional impairment, and decreased quality of life [1-6].

In adults, traumatic injuries such as ruptures of the anterior cruciate ligament (ACL) or posterior cruciate ligament (PCL) are among the most prevalent, frequently resulting from high-impact sports, accidents, or abrupt directional changes. These injuries are typically associated with acute pain, joint instability, and functional limitations, which, if not adequately managed, may lead to long-term consequences including chronic pain and early onset osteoarthritis [7-10]. The ACL, in particular, is essential for anterior-posterior and rotational stability of the knee, and its rupture often produces immediate symptoms such as a popping sensation, swelling, and significant instability during dynamic activities. In the subacute and chronic phases, patients may experience persistent discomfort, joint effusion, and mechanical symptoms that compromise physical performance [11-16].

In contrast, among the elderly population, degenerative conditions such as unilateral knee osteoarthritis (OA) are more commonly observed. OA is a progressive and multifactorial disease characterized by cartilage degradation, subchondral bone remodeling, osteophyte formation, and synovial inflammation. These pathological changes result in chronic joint pain, stiffness, crepitus, and reduced mobility, substantially affecting the individual's autonomy and overall health status [8,9]. The pain associated with OA develops insidiously and tends to worsen over time. It is typically exacerbated by weight-bearing activities such as walking or climbing stairs but can also occur at rest. Morning stiffness and stiffness after prolonged immobility are hallmark features of the disease, contributing to limitations in the range of motion and impacting daily activities [11-18].

Given the clinical relevance of both ACL injuries and knee OA, understanding the nature, perception, and progression of pain in these conditions is critical for developing effective therapeutic strategies. While ACL injuries are primarily associated with acute traumatic pain and mechanical instability, OA is marked by a chronic, inflammatory-degenerative pain process. Despite their distinct etiologies and demographic prevalence, both conditions share symptomatic overlaps that warrant comprehensive clinical assessment and targeted management.

The objective of this study is to analyze and compare the characteristics of acute and chronic pain in individuals diagnosed with anterior cruciate ligament rupture and unilateral knee osteoarthritis, encompassing a broad age spectrum including both adults and elderly individuals. This investigation seeks to deepen the understanding of how pain manifests, evolves, and is perceived across different age groups and pathological conditions, thereby informing more individualized and effective approaches to pain management and rehabilitation.

The objective of this study is to assess the characteristics of chronic and acute pain in individuals with anterior cruciate ligament rupture and unilateral knee osteoarthritis, encompassing a wide age range that includes both adults and elderly individuals. The research aims to deepen the understanding of how these conditions affect different age groups and how pain is perceived and managed in this context.

2. Methodology

2.1. Participants

The present study included a total of 34 volunteer participants, comprising both adults and elderly individuals of both sexes, distributed into two distinct groups according to their clinical diagnosis and the surgical procedure performed. Group 1 (G1) consisted of 20 elderly individuals, with a mean age of 71.59 ± 3.14 years, diagnosed with unilateral knee osteoarthritis and submitted to primary Total Knee Arthroplasty (TKA) under femoral nerve block anesthesia. Group 2 (G2) included 17 adult participants, with a mean age of 31.62 ± 6.23 years, diagnosed with complete rupture of the Anterior Cruciate Ligament (ACL), undergoing ACL reconstruction surgery, also with femoral nerve block anesthesia. Anthropometric and demographic data of the participants including age, height, body mass, and gender distribution are summarized in Table 1.

Group	Age (years)	Height (cm)	Body Mass (kg)	Gender
Group 1	71.59 ± 3.14	162 ± 16.21	80.63 ± 2.07	Male: 4 Female: 12
Group 2	31.62 ± 6.23	173 ± 8.41	72.15 ± 4.09	Male: 11 Female: 3
Legend: Data expressed as mean ± standard deviation.				

Table 1: Characteristics of the Study Participants

2.2. Ethical Considerations

The study was approved by the Research Ethics Committee of the Federal University of Goiás (CEP/UFG), under opinion number 24845019.20000.5083. All participants provided written informed consent by signing the Informed Consent Form (ICF), in accordance with the principles of autonomy, voluntariness, and confidentiality.

Participation was entirely voluntary, and individuals retained the right to withdraw at any stage without prejudice. The study also complied with Brazil's General Data Protection Law (LGPD – Law No. 13.709/2018), ensuring the privacy and security of all personal and health-related data.

2.3. Instruments and Procedures

To assess the intensity and characteristics of pain experienced by the participants, two validated instruments were applied to both groups. The Visual Analogue Scale (VAS) was used to quantify subjective pain perception. Participants were presented with a 10-centimeter horizontal line, with one end marked as "no pain" and the other as "the worst imaginable pain." They were instructed to mark a point on the line that best represented the intensity of pain they were feeling at that moment. The distance from the "no pain" end to the marked point was measured in millimeters, resulting in a score ranging from 0 to 10 [11-19].

In addition, the McGill Pain Questionnaire was employed to qualitatively evaluate the clinical profile of pain. This instrument comprises a structured set of descriptors organized into four major domains-sensory, affective, evaluative, and miscellaneous-totaling 78 terms distributed across 20 subgroups [20]. Subgroups 1 to 10 correspond to sensory qualities of pain; subgroups 11 to 15 relate to affective-emotional characteristics; subgroup 16 addresses evaluative aspects; and subgroups 17 to 20 include miscellaneous descriptors. Participants were asked to select the terms that best described their pain experience, including descriptors such as "throbbing," "burning," or "sharp" [12-19].

Pain assessments were carried out at three distinct time points: one hour before the surgical procedure (baseline), 24 hours after surgery, and 30 days postoperatively. This procedure allowed for both cross-sectional and longitudinal analyses of pain progression across the two surgical interventions.

2.4. Anesthetic Nerve Block Procedure

Both surgical interventions employed femoral nerve block anesthesia as a standardized analgesic strategy. A local anesthetic was injected adjacent to the femoral nerve to provide targeted sensory blockade of the anterior thigh and quadriceps muscle region [21,22].

This technique demonstrated effectiveness in minimizing postoperative pain, reducing the need for systemic analgesics, and mitigating related adverse effects [23,24]. Furthermore, it facilitated early mobilization—an essential component for successful rehabilitation and functional recovery [23,24].

2.5. Statistical Analysis

Pain intensity data from the VAS were analyzed as continuous variables on a 0–10 scale. Group comparisons were conducted using the Student's t-test for independent samples, with assumptions of normality checked prior to analysis. Scores from the McGill Pain Questionnaire were also compared between groups to evaluate differences in qualitative pain profiles. Statistical analyses were performed using Minitab software, version 21 for Windows, with a significance level set at $p \leq 0.05$.

3. Results

Table 2 presents the results of the Visual Analogue Scale (VAS) analysis. In Group 1, a reduction in pain intensity was observed, with the mean score decreasing from 9.76 (±8.99) before the surgical intervention to 6.16 (±1.29) after 30 postoperative days. In Group 2, pain intensity also decreased, from 3.76 (±3.41) before surgery to 0.71 (±2.39) after the same 30-day period. Both groups presented a p-value of 0.15, indicating that although there was a reduction in pain intensity, the difference was not statistically significant at the 5% significance level. These findings suggest a trend toward decreased postoperative pain intensity in both groups, although the reduction did not reach statistical significance. It is important to note that the use of anesthetic nerve block may have contributed to the postoperative pain relief observed.

Group	Preoperative Pain	24 Hours Postoperative	30 Days Postoperative	p-value
Group 1	9.76 (±8.99)	8.4 (±5.87)	6.16 (±1.29)	0.15
Group 2	3.76 (±3.41)	2.28 (±6.07)	0.71 (±2.39)	0.15
Legend: Group 1 – Unilateral Knee Osteoarthritis; Group 2 – ACL Injury. Data expressed as mean ± standard deviation. * Student's t-test.				

Table 2: Visual Analogue Scale (VAS) Pain Analysis

Table 3 displays the results from the McGill Pain Questionnaire, comparing acute pain (ACL injury) and chronic pain (unilateral knee osteoarthritis). Prior to surgery, Group 1 recorded a mean of 12.6 (±3.9) pain descriptors selected, while Group 2 showed a mean of 9.4 (±5.7). After 24 hours, Group 1 maintained a significantly higher mean than Group 2-11.7 (±6.9) vs. 6.21 (±3.4), respectively. This difference persisted at 30 days postoperatively, with Group 1 presenting a mean of 2.71 (±0.9) and Group 2 showing a slight increase to 5.23 (±3.1). All these differences were statistically significant, indicating a more pronounced reduction in pain perception in Group 1 compared to Group 2 ($p < 0.001$).

Variable	G1 – Pre	G2 – Pre	G1 – 24h Post	G2 – 24h Post	G1 – 30 Days	G2 – 30 Days	p-value
Number of Words Chosen (NWC)	12.6 (±3.9)	9.4 (±5.7)	11.7 (±6.9)	6.21 (±3.4)	2.71 (±0.9)	5.23 (±3.1)	< 0.001*

Pain Rating Index – Total (PRI-T)	17.6 (±10.9)	14.93 (±10.4)	13.5 (±11.5)	7.69 (±6.1)	3.57 (±3.6)	2.78 (±8.3)	0.34
PRI – Sensory Dimension (PRI-S)	14.8 (±5.9)	10.0 (±9.8)	12.7 (±9.7)	8.93 (±10.4)	6.78 (±6.4)	9.62 (±10.9)	0.72
PRI – Affective Dimension (PRI-A)	10.0 (±9.9)	3.54 (±5.4)	7.21 (±4.5)	5.09 (±6.4)	0.00 (±0.0)	1.61 (±0.21)	0.001*
Legend: Group 1 – Unilateral Knee Osteoarthritis; Group 2 – ACL Injury. Data expressed as mean ± standard deviation. * Student's t-test.							

Table 3: McGill Pain Questionnaire: Acute Pain (ACL Injury) vs. Chronic Pain (Unilateral Knee Osteoarthritis)

In the Total Pain Rating Index (PRI-T), differences between groups were not statistically significant at any of the measurement points. However, regarding the Sensory Pain Rating Index (PRI-S), a statistically significant difference was observed between the groups only in the preoperative period, with Group 1 presenting a mean of 14.8 (±5.9) and Group 2 reporting 10.0 (±9.8).

The most notable statistically significant difference was found in the Affective Pain Rating Index (PRI-A). Before surgery, Group 1 had a mean score of 10.0 (±9.9), compared to 3.54 (±5.4) in Group 2, indicating a highly significant difference ($p = 0.001$*). This disparity remained consistent at both 24 hours and 30 days postoperatively, highlighting a marked distinction in pain perception between the groups—particularly in the affective dimension of pain.

4. Discussion

Pain is a complex and multifaceted experience, influenced by a variety of physical and psychological factors. Effective assessment and management of pain require a comprehensive understanding of these factors and how they interact to shape the individual perception of pain [25].

Pain can be classified in several ways: according to its site of origin, pathophysiological mechanism, and duration (acute or chronic). Acute pain is typically transient, lasting from a few minutes to several weeks. When inadequately managed, it may contribute to the development of chronic pain. In contrast, chronic pain persists for more than three months beyond the usual healing period of an injury or is associated with ongoing pathological processes that result in continuous or recurrent pain. For non-oncological musculoskeletal pain, the three-month threshold is widely used to distinguish acute from chronic pain, although a six-month period is also frequently adopted in research contexts [26].

The prevalence of chronic pain in the Brazilian population is approximately 45.59%, a high rate that is also observed in developed countries such as Japan, China, and the United States, as well as in developing countries like Iran. This suggests that the presence of chronic pain is not directly linked to a nation's economic status [27].

Research on pain assessment is highly relevant, as chronic pain represents a global public health issue with major consequences, such as increased demand for medical consultations and medications, limitations in daily and occupational activities, compromised mental health, and reduced quality of life (QoL). Moreover, such studies can support clinical decision-making by multidisciplinary teams [28-30].

Given that pain is a subjective experience, there is no gold-standard scale for its measurement. As a result, various instruments are used to assess pain. Unidimensional tools, such as the Visual Analogue Scale (VAS), quantify only the intensity of pain and its relief. VAS is widely used in clinical settings due to its ease and speed of administration. In contrast, multidimensional instruments, such as the McGill Pain Questionnaire and signal detection theory, evaluate various dimensions of the pain experience using multiple indicators and their interactions. In the present study, both unidimensional and multidimensional instruments were employed for pain assessment [31-34].

VAS data presented in Table 1 show a reduction in pain intensity in Group 1 following surgical intervention. Similarly, a decrease in pain was observed in Group 2 after surgery. Although both groups demonstrated reductions in pain intensity, these differences were not statistically significant, suggesting a trend toward postoperative pain attenuation—possibly influenced by the use of anesthetic nerve block[35]. It is worth emphasizing that the nerve block technique may have played a significant role in the reduction of postoperative pain [36-42].

The results indicate that Group 2, composed of adults with Anterior Cruciate Ligament (ACL) injury, experienced significantly higher pain perception than Group 1, consisting of elderly individuals with unilateral knee osteoarthritis. This difference was evident both before surgery and at 24 hours and 30 days postoperatively. The persistence of this difference suggests that acute pain related to ACL injury may be more intense or more difficult to manage than the chronic pain associated with osteoarthritis [32-42].

However, it is important to recognize that pain perception is highly subjective and can be influenced by various factors, including the individual's physical and mental condition and their personal pain history [30-42]. In the Total Pain Rating Index (PRI-T), no significant differences were observed between the groups at any of the measurement points, suggesting that despite variations in pain perception, the overall pain experience-including aspects such as duration, peak intensity, and average pain over time-may not differ substantially between the two groups [30-42].

Nonetheless, significant differences were observed in the Sensory Pain Rating Index (PRI-S) and the Affective Pain Rating Index (PRI-A). This indicates that although the total pain score may be similar, the way in which pain is experienced differs between groups. For instance, Group 1 may have perceived the pain as more intense or more disruptive to daily activities. Furthermore, pain may have had a greater impact on emotional state, as demonstrated by the higher scores in the affective dimension of pain [35-42].

These findings highlight the complexity of the pain experience and underscore the importance of comprehensive approaches to pain management. These approaches must consider pain intensity, its experience, and its impact on daily life and emotional well-being [37-40].

Anesthetic nerve block emerges as a promising strategy for postoperative pain relief in both Group 1 and Group 2. This technique, which involves the administration of local anesthetics to block the transmission of pain signals, has become increasingly used for surgical anesthesia and postoperative analgesia [21-24]. Its benefits include early recovery, improved rehabilitation quality, reduced opioid requirements, and increased patient satisfaction [22-24]. Furthermore, the multimodal approach, which combines various analgesic strategies, is recognized as an effective means of achieving comprehensive pain control [22-24].

In conclusion, pain is a highly individual experience that can vary widely even among individuals with similar conditions. Effective pain management often requires a personalized approach tailored to the specific needs of each patient [36-42].

5. Conclusion

The findings of this study underscore the intrinsic complexity of pain and the pressing need for a comprehensive approach to its management. Although variations in pain intensity were observed across different medical conditions-as evidenced by the marked disparity in pain perception between the groups studied-the Total Pain Rating Index did not reveal substantial differences in the overall pain experience.

However, the analysis of the Sensory and Affective Pain Rating Indices demonstrated significant distinctions in how patients subjectively experienced pain, emphasizing the importance of considering not only the intensity of pain but also its emotional and functional impact on the individual's daily life.

Furthermore, interventions such as anesthetic nerve block and multimodal analgesia emerged as promising strategies for improving postoperative pain management, offering concrete benefits including faster recovery, reduced reliance on opioid analgesics, and lower overall pain levels.

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