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THE EFFECTS OF COMBINED PROGRESSIVE MUSCLE RELAXATION (PMR) AND BINAURAL BEAT (THETA WAVE) STIMULATION ON PAIN INTENSITY AND ANALGESIC USE IN POST-URETEROSCOPY (URS) PATIENTS WITH URINARY TRACT STONES

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ABSTRACT
Urinary tract stones are a common urological disorder in Indonesia and around the world. One common medical procedure used to treat urinary tract stones is ureteroscopy (URS). This case study aims to evaluate the combined effect of Progressive Muscle Relaxation (PMR) therapy and binaural sound stimulation (theta waves) on pain intensity and analgesic needs in patients following ureteroscopy (URS) for urinary tract stones. The method used was an experimental design with a pre-test and post-test design in four patients who met the inclusion criteria. The intervention was carried out once daily for 15–20 minutes, with blood pressure, pulse rate, and pain scale measurements before and after therapy. The data were analyzed descriptively by comparing pre- and post-intervention measurements to evaluate changes in pain intensity, blood pressure, pulse rate, and analgesic requirements following the combined PMR and binaural beat therapy. The results showed that all patients experienced a decrease in pain intensity from moderate (scale 5–7) to mild (scale 2–4), accompanied by a decrease in blood pressure and pulse rate after the intervention. These results indicate a relaxation response and decreased sympathetic nervous system activity. The combination of PMR and binaural sound stimulation has been shown to be effective as a safe and easy-to-implement non-pharmacological intervention in pain management after minimally invasive urological procedures.

Keywords: binaural sound; postoperative pain; progressive muscle relaxation; ureteroscopy

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INTRODUCTION

Urinary tract stone disease is a relatively common urological disorder in Indonesia and worldwide (Salatin, 2024). Urinary tract stones (urolithiasis) are defined as the formation of mineral crystals that precipitate within the urinary tract, including the kidneys, ureters, bladder, and urethra (Mukid, 2023). Epidemiological data indicate that the prevalence of urinary tract stones in Indonesia is estimated to be approximately 0.6% of the total population, with higher rates reported in several provinces, such as 1.2% in the Special Region of Yogyakarta and 0.9% in Aceh, as well as around 0.8% in Central Java and West Java (Kemenkes, 2021). These data demonstrate that this condition represents a significant health burden, as it can cause severe pain, urinary flow obstruction, infection, and other complications requiring further medical management (Kemenkes, 2021).

One of the commonly used medical procedures for the management of urinary tract stones is ureteroscopy (URS) (Mukid, 2023). URS is considered a minimally invasive technique that is effective in fragmenting and removing stones without requiring large incisions, with high success and stone-free rates compared to several alternative treatment modalities (Auliany & Sholihin,

2024). However, although ureteroscopy (URS) is categorized as a minimally invasive procedure, patients frequently experience postoperative pain due to tissue trauma, ureteral irritation, ureteral muscle spasm, and other procedural manipulations. Postoperative pain may hinder patient mobilization, reduce sleep quality, and prolong the length of hospital stay if not properly managed (Shauqy et al., 2022). Conventional pain management primarily relies on the administration of pharmacological analgesics (Sudaryanti et al., 2023). Although this approach is effective, it has limitations, including the risk of side effects such as nausea, sedation, gastrointestinal disturbances, and the potential for dependency when used intensively. Therefore, current clinical practice recommendations emphasize the important role of non-pharmacological strategies as part of comprehensive pain management (Sulastri, 2024).

One of the non-pharmacological approaches that has been widely studied for pain management is Progressive Muscle Relaxation (PMR) (Holis et al., 2024). PMR is a relaxation technique that involves systematically tensing and relaxing different muscle groups, thereby reducing muscle tension, calming the sympathetic nervous system, and helping to decrease pain perception (Rosiska, 2025). Case reports and previous studies have demonstrated that PMR is effective in reducing pain intensity in patients following minimally invasive urological procedures, such as after percutaneous nephrolithotomy (PCNL) or ureteroscopic lithotripsy for kidney stones, with a significant reduction in pain scores after the progressive muscle relaxation intervention (Faidah et al., 2025). The mechanism by which PMR reduces pain includes the relaxation of body muscles, thereby decreasing the transmission of pain signals to the brain (Dwi et al., 2025). This relaxation response also enhances parasympathetic nervous system activity, promoting a calmer physiological state and reducing the stress response (Lestaluhu et al., 2024). These relaxation effects are consistent with the Gate Control Theory of Pain, which proposes that pain modulation can occur through non-nociceptive stimuli that "close the pain gate" at the level of the spinal cord, ultimately reducing the number of pain signals reaching the cerebral cortex (Holis et al., 2024).

In addition to PMR, binaural beat sound stimulation has emerged as another non-pharmacological intervention with the potential to influence pain perception and patients' psychophysiological conditions (Loong et al., 2022). Binaural beats operate through a mechanism known as brainwave entrainment, in which two slightly different sound frequencies are presented separately to each ear, leading the brain to generate a perceived third frequency (e.g., theta waves in the 4–7 Hz range) associated with relaxation, calmness, and stress reduction (Khasanah & Suratih, 2020). Several studies and meta-analyses have reported that binaural beat stimulation has a positive effect on reducing perioperative anxiety and pain compared to control conditions, as well as promoting more stable hemodynamic outcomes in surgical patients (Loong et al., 2022). The mechanism of binaural sound stimulation may alter brainwave patterns, enhance parasympathetic activity, and attenuate the stress response, which in turn can influence pain perception and patients' analgesic requirements (Ridho et al., 2023).

Based on this evidence, the present study aims to evaluate the effect of a combined intervention of Progressive Muscle Relaxation (PMR) therapy and binaural beat sound stimulation (theta waves) on pain intensity and analgesic requirements in patients following ureteroscopy for urinary tract stones. It is expected that the findings will contribute to the development of more effective, safe, and evidence-based nursing care strategies in the management of pain after minimally invasive urological procedures.

METHOD

The implementation of Evidence-Based Nursing Practice (EBN) in this study involved the administration of a combined therapy consisting of Progressive Muscle Relaxation (PMR) and binaural beat sound stimulation (theta waves) to assess its effects on pain intensity and analgesic requirements in patients following ureteroscopy for urinary tract stones. The intervention was

conducted using an experimental (treatment) approach in patients who underwent ureteroscopy for urinary tract stones. The effectiveness of the intervention was evaluated using pre- and post-intervention measurements of pain intensity and analgesic requirements after the application of the combined PMR and binaural beat (theta wave) therapy. The therapy was administered once daily with a duration of 15–20 minutes. Baseline (pre-intervention) measurements of blood pressure, pulse rate, and pain intensity using the Numeric Rating Scale (NRS) were obtained prior to the intervention. Subsequently, patients received the combined Progressive Muscle Relaxation (PMR) therapy while simultaneously listening to theta-frequency binaural beats (4–7 Hz) through headphones. After completion of the session, post-intervention evaluations were conducted by reassessing blood pressure, pulse rate, and pain intensity using the Numeric Rating Scale (NRS).

The subjects who received the intervention consisted of four patients who met the inclusion criteria: post-ureteroscopy patients with urinary tract stones, experiencing mild to moderate pain, and willing to participate in the intervention. The exclusion criteria included patients with hearing impairment, cognitive disorders, or post-procedural complications. The collected data were analyzed descriptively by comparing pre- and post-intervention measurements of blood pressure, pulse rate, pain intensity, and analgesic requirements in each patient. The results were presented in the form of tables and narrative descriptions to identify changes that occurred after the administration of the combined Progressive Muscle Relaxation (PMR) and binaural beat (theta wave) therapy.

RESULT

Table 1
The results of the intervention implementation are presented in the following table

Name	Pre			Post		
	Blood pressure	Pulse rate	Pain score	Blood pressure	Pulse rate	Pain score
Mr. A	145/95 mmHg	98x/minute	6	125/80 mmHg	82x/minute	3
Mr. S	138/90 mmHg	92x/minute	5	122/85 mmHg	78x/minute	2
Mrs. R	150/98 mmHg	105x/ minute	7	135/88 mmHg	88x/minute	4
Mrs. P	142/92 mmHg	96x/ minute	6	128/82 mmHg	80x/minute	3

Based on table 1, the results of the combined Progressive Muscle Relaxation (PMR) therapy and binaural beat sound stimulation (theta waves) in four patients following ureteroscopy (URS) for urinary tract stones demonstrated consistent physiological changes and reductions in pain intensity across all patients. All patients experienced decreases in blood pressure, pulse rate, and pain scores after the intervention. Prior to the intervention, most patients were categorized as experiencing moderate pain, with pain scores ranging from 5 to 7. After the intervention, pain scores decreased to the mild pain category, ranging from 2 to 4. In addition, reductions in both systolic and diastolic blood pressure, as well as pulse rate, were observed, indicating a relaxation response in post-URS patients.

In patient Mr. A, the pre-intervention measurements showed a blood pressure of 145/95 mmHg, a pulse rate of 98 beats per minute, and a pain score of 6 (moderate pain). After the intervention, blood pressure decreased to 125/80 mmHg, pulse rate to 82 beats per minute, and the pain score to 3, indicating improvement to mild pain. This suggests a relaxation response and reduced sympathetic nervous system activation following the intervention. Patient Mr. S presented with an initial blood pressure of 138/90 mmHg, pulse rate of 92 beats per minute, and a pain score of 5 prior to the intervention. After the therapy, blood pressure decreased to 122/85 mmHg, pulse rate to 78 beats per minute, and the pain score to 2. These findings indicate that the combination of PMR and binaural beat stimulation was effective in reducing pain and stabilizing vital signs after URS.

In patient Mrs. R, pre-intervention measurements included a blood pressure of 150/98 mmHg, pulse rate of 105 beats per minute, and a pain score of 7, categorized as moderate to severe pain. Following the intervention, blood pressure decreased to 135/88 mmHg, pulse rate to 88 beats per minute, and the pain score to 4. Although pain was still present, a clinically meaningful reduction in pain intensity and improvement in vital signs were observed, indicating the relaxation effect of the intervention. Similarly, patient Mrs. P had a pre-intervention blood pressure of 142/92 mmHg, pulse rate of 96 beats per minute, and a pain score of 6. After the intervention, blood pressure decreased to 128/82 mmHg, pulse rate to 80 beats per minute, and the pain score to 3. These results demonstrate a reduction in pain from moderate to mild, accompanied by stabilization of physiological responses. Overall, the findings indicate that all patients experienced reductions in blood pressure, pulse rate, and pain scores following the combined PMR and binaural beat (theta wave) therapy. The decrease in vital signs reflects a physiological relaxation response, while the reduction in pain scores demonstrates the effectiveness of this non-pharmacological intervention in supporting postoperative pain management after ureteroscopy. These results support the application of combined PMR and binaural beat stimulation as a safe and beneficial complementary nursing intervention in clinical practice.

DISCUSSION

The results of the implementation of the combined Progressive Muscle Relaxation (PMR) therapy and binaural beat sound stimulation (theta waves) in patients following ureteroscopy (URS) demonstrated reductions in pain intensity (Numeric Rating Scale), decreases in vital signs (blood pressure and pulse rate), and reduced analgesic requirements among all respondents. These findings indicate that this non-pharmacological intervention exerts a therapeutic effect on pain modulation and physiological responses in patients after urological surgical procedures. Progressive Muscle Relaxation (PMR) is a relaxation technique that operates through systematic muscle contraction and relaxation, thereby reducing muscle tension, decreasing sympathetic nervous system activity, and enhancing parasympathetic dominance associated with relaxation and reduced pain perception (Fitriani et al., 2020). Studies conducted in Indonesia have shown that PMR effectively reduces blood pressure and pain intensity in patients with urinary tract stones, with significant reductions in pain scores (for example, from a mean of 5.39 to 2.88) and systolic blood pressure following the intervention (Widyastuti & Nopriani, 2024).

Furthermore, scientific literature reviews indicate that PMR is effective in reducing both acute and chronic pain across various clinical conditions, including postoperative patients and individuals with musculoskeletal pain. These findings are supported by studies demonstrating reduced postoperative pain following debridement procedures when PMR was administered for 15–20 minutes per session, as well as reductions in headache intensity and anxiety in patients with hypertension (Hamzah et al., 2025). These findings are consistent with the Gate Control Theory of Pain, which proposes that pain perception can be modulated by non-nociceptive stimuli that “close the pain gate” at the spinal cord level, thereby reducing the number of pain signals reaching the cerebral cortex (Astutik & Yanto, 2023). Relaxation techniques such as PMR may divert attention from pain sensations and reduce muscle tension that triggers sympathetic responses, which can exacerbate pain perception. In addition, PMR enhances parasympathetic activity, leading to reductions in pulse rate and blood pressure, as also observed in the present case study (Faridah et al., 2025). Research by (Widyastuti & Nopriani, 2024) demonstrated that routine administration of PMR significantly reduced pain intensity and stabilized vital signs in patients following medical procedures. Similarly (Holis et al., 2024) reported that PMR effectively decreased acute postoperative pain and improved physiological responses, including reductions in blood pressure and pulse rate. These findings are consistent with the results of the present study, in which all patients experienced decreases in blood pressure and pulse rate after the intervention.

Physiologically, PMR reduces pain through mechanisms involving endorphin release and decreased stress hormones such as cortisol and adrenaline (Nisa et al., 2023). The reduction in stress hormones contributes to decreased muscle tension, reduced anxiety, and increased pain threshold. Therefore, PMR may be utilized as a safe and effective independent nursing intervention in the management of postoperative pain following URS (Wulandari et al., 2020). Meanwhile, binaural beat sound stimulation at theta frequency (4–7 Hz) also plays an important role in reducing pain intensity in patients after URS (Loong et al., 2022). Binaural beats function through brainwave entrainment, a process in which brainwave activity synchronizes with externally presented auditory frequencies received through the auditory system (Hadjileontiadis & Kouvelas, 2020). Theta waves are associated with deep relaxation, calmness, and anxiety reduction. In this state, parasympathetic nervous system activity increases, promoting physiological relaxation and consequently reducing pain perception. Neurophysiological theory suggests that deep relaxation states may reduce activity in the sensory cortex involved in pain perception (Shamsi et al., 2024).

The findings of this case study are consistent with research by (Febtrina et al., 2025) which reported that binaural sound stimulation effectively reduced pain and anxiety in perioperative patients. Patients who received binaural sound therapy demonstrated significantly greater reductions in pain scores compared to those who did not receive the intervention. Other relevant studies have shown that theta-frequency binaural beats may reduce postoperative analgesic requirements. (Shamsi et al., 2024) found that patients who listened to binaural beats experienced significant reductions in pain and anxiety compared to control groups. Binaural sound stimulation influences the limbic system, which plays a crucial role in emotional regulation and pain perception. More stable limbic system activation may reduce emotional responses to pain, allowing patients to feel calmer and more comfortable. This mechanism supports the observed reductions in vital signs, such as blood pressure and pulse rate, as found in the present study (Febtrina et al., 2025). Based on the above discussion, it can be concluded that the combined application of PMR and binaural beat stimulation provides positive effects in reducing postoperative pain following URS. This therapy is highly relevant in clinical practice because it is easy to implement, does not require complex equipment, and does not produce adverse side effects. Furthermore, this intervention supports a holistic nursing approach that addresses both the physical and psychological aspects of patient care.

CONCLUSION

Based on the results of the implementation of combined Progressive Muscle Relaxation (PMR) and binaural beat sound stimulation (theta waves) on pain intensity and analgesic requirements in patients following ureteroscopy (URS) for urinary tract stones, it can be concluded that the combined PMR and binaural beat therapy effectively reduced pain intensity in post-ureteroscopy patients. This was demonstrated by a reduction in pain scores from the moderate pain category to mild pain in all patients. The administration of the combined intervention also showed improvements in physiological responses, including reductions in blood pressure and pulse rate, indicating a relaxation response and decreased sympathetic nervous system activity.

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