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Differential diagnosis and management of cartilage-derived tumors in the upper extremity: a focus on osteochondroma and bizarre parosteal osteochondromatous proliferation

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ABSTRACT

Aims: Among cartilage-derived tumors in the hand, osteochondroma is the second most common benign lesion after enchondromas. Bizarre parosteal osteochondromatous proliferation (BPOP) is particularly rare in the hand and may be confused with malignant processes. This study presents the outcomes of surgically treated exophytic benign bone masses. The aim is to differentiate between these two lesions, which are very similar clinically, radiologically, and histopathologically.

Methods: Nine patients who underwent surgery due to a mass in the hand, with a histopathological diagnosis of osteochondroma-BPOP, were included in the study. Surgeries were performed under axillary anesthesia by a single surgeon certified in hand surgery. The demographic data of the patients, characteristics of the mass, and associated clinical findings were recorded. Functional outcomes at the final outpatient follow-up after mass excision were assessed using VAS and q-DASH scores. Surgical complications and recurrence were also investigated.

Results: The average age of the patients participating in the study was 40 years (range: 14-64 years). The average follow-up period after surgery was 30 months (range: 8-120 months). A total of 9 patients underwent surgery due to a palpable mass, with histopathologically confirmed diagnoses reporting 6 cases of solitary osteochondroma and 3 cases of BPOP. During the follow-up period, 1 patient developed a recurrent mass, and this patient with a diagnosis of BPOP underwent reoperation. Clinically, all patients experienced a resolution of preoperative complaints, and significant improvements were observed in clinical scores.

Conclusion: Symptomatic classical osteochondroma and BPOP lesions cause concern for patients. Successful outcomes can be achieved through surgical excision. However, after excluding malignancy, it is important to differentiate between these lesions. It will be beneficial to be aware of the high recurrence rates in cases considered similar to osteochondroma excision, such as BPOP lesions, and to maintain a diligent follow-up.

Keywords: Hand, benign, osteochondroma, bizarre parosteal osteochondromatosis proliferation

INTRODUCTION

The differential diagnosis of tumors and tumor-like lesions in the upper extremity, particularly in the hand and wrist, is quite broad.^{1,2} Cartilage-derived masses are often benign, with enchondromas being the most frequently encountered among these lesions.^{3,4} Although osteochondromas are also commonly seen cartilage-derived tumors, they are relatively rare in the hand and typically occur in long bones such as the humerus and femur.^{5,6} In contrast to osteochondromas, bizarre parosteal osteochondromatous lesions (Nora lesions) (BPOP), which are morphologically very similar to this tumor and cannot be distinguished from osteochondroma macroscopically, are more often found in the hand and foot.^{7,8}

Hand osteochondromas and BPOP are clinically very similar, generally presenting as asymptomatic palpable masses.

However, if they are located in pressure points, they can cause pain and numbness. An important difference between these two masses is that, unlike osteochondromas, Nora lesions do not have continuity with the cancellous bone at the site of the lesion.⁹ Although both lesions are benign, the risk of malignant transformation leading to secondary chondrosarcoma in osteochondromas is present even in solitary lesions at a rate of approximately 1%.^{10,11} BPOP is much less common than osteochondroma, but the local recurrence rate is considerably high.¹² For this reason, distinguishing between these clinically similar lesions may be important for predicting recurrence.

In this study, we share the outcomes of nine cartilage-derived masses, excluding enchondromas, surgically treated in the hand and wrist. We aim to demonstrate that, in addition to

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commonly seen osteochondroma cases, rare lesions such as BPOP could also be present.

METHODS

This study received ethical approval from the ethics committee of İnönü University Scientific Researches and Publication Ethics Committee (Approval Date: 05.11.2024, Decision No: 2024/6462). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. It is a retrospective study that includes 9 patients assessed for a mass in the hand at the hand surgery outpatient clinic between 2018 and 2022. Patients who were surgically treated for hand masses and diagnosed pathologically as osteochondroma-BPOP, as well as patients diagnosed with osteochondroma excluding hereditary multiple exostoses syndrome, were included in the study, based on complete electronic file records and outpatient follow-ups. Patients who were conservatively followed for hand masses, those who underwent surgery for hand masses and received a pathological diagnosis other than osteochondroma-BPOP, and those with incomplete or irregular outpatient records were excluded from the study.

During outpatient visits, a detailed medical history was initially taken and complaints were investigated. Symptoms such as pain, numbness, and restricted movement were recorded, and the mass in the hand was assessed through physical examination. Questions regarding the presence of comorbidities and whether the patient had any masses in areas other than the hand were asked in the investigation. Three-dimensional imaging of the hand and wrist was requested according to the affected area. In order to evaluate the bone structure, computed tomography scans were performed, particularly for smaller masses when necessary. Contrast-enhanced magnetic resonance imaging was requested for all patients to assess the relationship of the mass with the surrounding soft tissue (Figure 1, 2). Following these investigations, surgical treatment was recommended for patients with bone masses suspected based on the preliminary diagnosis, and who were not considered malignant based on imaging results. Also, given the patient's medical history and the history of the mass (duration), and taking into account the presence of a cartilaginous cap on the radiological images, a preoperative biopsy was not planned.

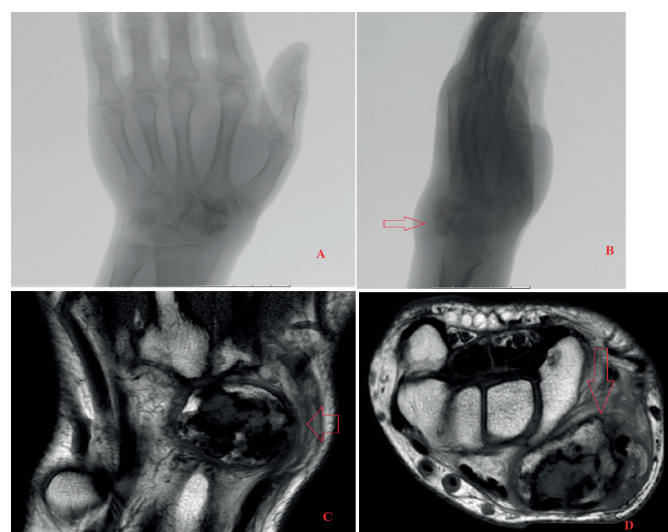


Figure 1. A 64-year-old male patient with a mass in his wrist. Preoperative X-Rays (A, B) and MRI images (C, D) of the patient. The mass has no medullary continuity with the carpal bones, and the diagnosis is BPOP (red arrows)

MRI: Magnetic resonance imaging

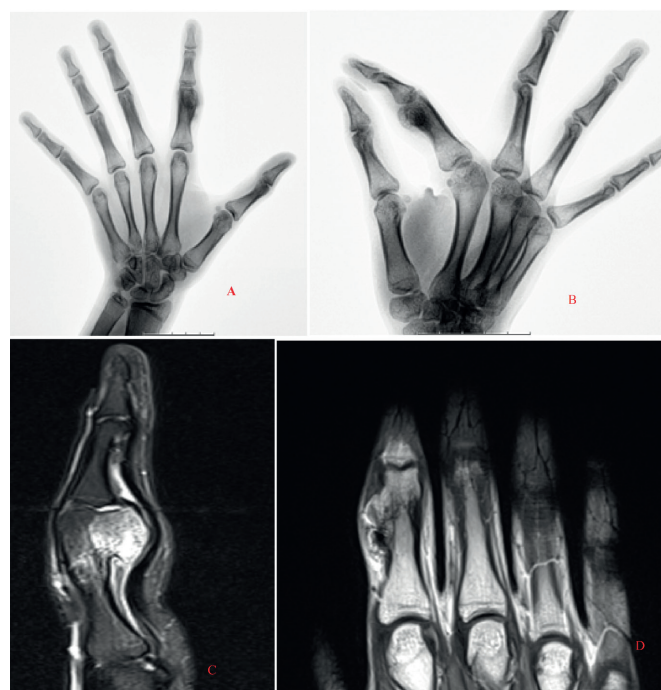


Figure 2. A 14-year-old female patient. A bone mass in the distal part of the proximal phalanx of the second finger. X-Ray (A, B) and MRI images (C, D) of the mass. Osteochondroma is detected after excision

MRI: Magnetic resonance imaging

All surgeries were performed by a single experienced surgeon certified in hand surgery (X. X). The procedures were conducted under axillary anesthesia with the assistance of a tourniquet. Access to the masses was assessed based on anatomical location and preoperative imaging methods, and volar-dorsal approaches were used for the hand and wrist (Figure 3, 4). During all operations, soft tissue dissection was performed in accordance with hand surgical principles, and the masses were excised via marginal resection. Excisional specimens were sent to the pathology laboratory for analysis. In the postoperative follow-up, patients were monitored with a short arm splint until soft tissue healing was achieved, typically until the second week. Sutures were removed in the second week, the splint was discontinued, and the patients were allowed to perform movements of the hand and wrist. Outpatient follow-ups were conducted at the 2nd week, 2nd month, 6th month, and annually.



Figure 3. Intraoperative images of BPOP localized at the wrist. Preoperative (A), surgical exposure (B), excision material (C), surgical field (D)

BPOP: Bizarre parosteal osteochondromatous proliferation

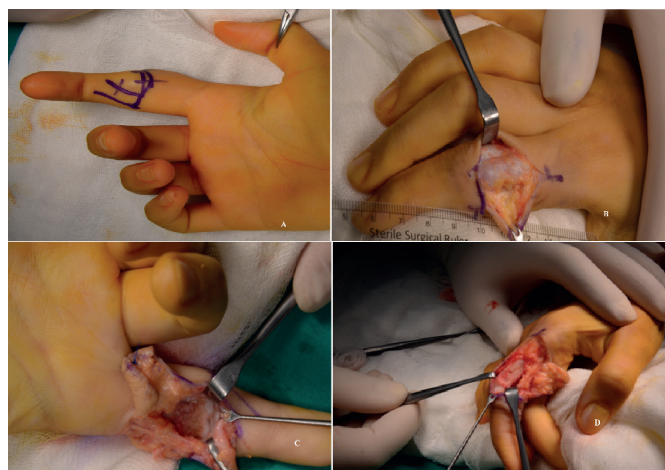


Figure 4. Intraoperative images of osteochondroma located in the proximal phalanx. Preoperative (A), mass exposure (B), post-excision (C, D)

Demographic data of the patients, preoperative complaints related to the masses, the duration and location of the masses, as well as preoperative and postoperative VAS and Q-DASH scores were recorded. Patient clinical satisfaction was evaluated using a subjective satisfaction scale (very satisfied-satisfied-neutral-unsatisfied) following surgery. Potential postoperative complications and the development of recurrent masses were also investigated.

In the study, qualitative data were summarized using counts (percentages). Quantitative data were summarized using median (minimum-maximum) and mean±standard deviation. In statistical analyses, categorical variables were compared using Fisher’s exact Chi-square test. For analyses involving two dependent quantitative variables, the Wilcoxon signed-rank test was used. A p-value of <0.05 was considered statistically significant in all applied statistical analyses. All analyses were conducted using IBM SPSS Statistics 26.0 for Windows (New York, USA).

RESULTS

The average duration from the first notice of the mass in the affected upper extremity to the date of surgery was 30 months (range: 8-120 months). Among the nine patients, 6 were female and 3 were male. The average age of the patients participating in the study was 40 years (range: 14-64 years). The demographic data of the patients and the characteristics of the masses that were surgically treated are presented in **Table 1**.

Among the 9 patients who underwent surgery for a mass in the hand, the diagnosis was osteochondroma in 6 patients

and BPOP in 3 patients. Of the 9 patients in the study, 6 (66.7%) were female, and 3 (33.3%) were male. Six cases (66.7%) were operated on the right side, while 3 cases (33.3%) were operated on the left side. The most common clinical complaint was pain, which was noted in 7 patients (77.78%). Two patients (22.22%) were surgically treated due to isolated swelling without any complaints. The most common mass location in the upper extremity was the phalanx, observed in 6 patients. Masses were operated on at the metacarpal level in 2 patients and at the wrist level in 1 patient. When examining recurrence, no recurrence was observed in 8 patients (88.9%), while recurrence developed in 1 patient (11.1%). Secondary surgery due to recurrence was performed on 1 patient (11.1%) diagnosed with BPOP. The evaluation of the clinical outcomes of the patients is presented in **Table 2**.

Table 2. Determination of clinical outcomes before and after surgery using scores

Measurement	Median (min-max)	p-value
Preoperative VAS	8 (7-10)	0.007
Postoperative VAS	1 (1-3)	
Preoperative QDASH	68 (45-86)	0.008
Postoperative QDASH	20 (10-36)	
Subjective satisfaction score	n (%)	
Excellent	4 (44.4%)	
Good	5 (55.6%)	
Fair	0	
Poor	0	

Min: Minimum, Max: Maximum, VAS: Value-added services, QDASH: Quick disabilities of the arm, shoulder, and hand

When evaluating the clinical outcomes of the patients, the changes in preoperative and postoperative VAS and Q-DASH scores were statistically significant (p-values of 0.007 and 0.008, respectively). Additionally, in the assessment of subjective clinical well-being, good results were achieved in 5 patients (55.6%) and very good results in 4 patients (44.4%). There were no moderate or poor results.

The most common complication observed after surgery was nonspecific numbness in the incision area, reported in 4 patients (44.4%), which did not clinically reflect any issues. No additional surgical procedures were performed for this condition. One patient with numbness had also experienced numbness prior to surgery. However, these two clinical presentations differed in severity and localization. No wound healing problems or infections were observed in any of the patients.

Table 1. Patient and mass characteristics

Patients	Gender	Age	Side	Complaint	Localization	Pathological diagnosis	Recurrence	Follow-up period (months)
1	Female	53	Right	Pain	Proximal Phalanx	Osteochondroma	No	13
2	Female	58	Right	Pain	Proximal Phalanx	BPOP	No	25
3	Male	64	Right	Pain	Carpus	BPOP	No	8
4	Male	38	Right	Pain+weakness	Metacarp	BPOP	Yes	24
5	Female	50	Left	Pain+weakness	Proximal Phalanx	Osteochondroma	No	27
6	Male	22	Right	Swelling	Proximal Phalanx	Osteochondroma	No	16
7	Female	22	Left	Pain+numbness	Metacarp	Osteochondroma	No	19
8	Female	14	Right	Pain+weakness	Proximal Phalanx	Osteochondroma	No	18
9	Female	37	Left	Swelling	Middle Phalanx	Osteochondroma	No	120

BPOP: Bizarre parosteal osteochondromatous proliferation

DISCUSSION

In patients undergoing surgery for a mass in the upper extremity, particularly in the hand and wrist, the most common bone-origin pathology aside from soft tissue lesions is osteochondroma, excluding enchondromas. Preoperative imaging may reveal the rare entity of BPOP following osteochondroma excision. The surgeon should be aware of these two distinct clinical conditions and provide appropriate counseling to the patient and their family members. First and foremost, malignancy should be excluded, recognizing that osteochondroma carries minimal malignant potential, whereas BPOP may mimic a malignant process because of its tendency for local recurrence. Although osteochondroma is a common cartilage-derived tumor, its occurrence in the upper extremity especially in the hand and wrist is considered atypical. Conversely, while hand involvement is typical in BPOP, the condition itself remains rare.

To accurately differentiate between these two lesions, a clear understanding of their characteristic features is essential. Osteochondromas may present as solitary lesions or as multiple lesions associated with genetic conditions such as hereditary multiple exostoses, in which the risk of malignancy increases.¹³ The typical age of presentation is under 20 years, with a predominance in females.¹¹ In contrast, BPOP has been associated with chromosomal abnormalities¹⁴ and is generally observed in older individuals, most commonly in the third decade of life, with no gender predominance.¹⁵

In our series, a higher incidence of osteochondroma was noted in female patients, particularly during the second decade of life. The predominance of the female gender was statistically significant among osteochondroma patients. Older age groups are especially relevant when considering BPOP. Even when only demographic data are taken into account, surgeons may develop an initial suspicion that helps differentiate between these two types of masses.

In terms of localization, although the typical site for hand osteochondromas is not clearly defined, they are more likely to occur in the proximal phalanx.⁵ BPOP lesions, on the other hand, are generally located in the metacarpal and phalangeal regions.⁷ Atypical cases of BPOP have also been reported in the carpal-wrist area and the distal ulna.^{16,17} In our series, we excised a large BPOP mass located in the wrist in one case, while the other two masses were situated in the phalangeal and metacarpal regions. A considerable proportion of the osteochondromas we operated on originated from the proximal phalanx, making this finding noteworthy in terms of localization.

Although swelling of the hand and its progressive growth may be asymptomatic, it is a source of concern for patients. A definitive diagnosis must be established, and malignancy should be excluded. Key initial considerations include the history of the mass, its duration, tenderness on palpation, and the physical characteristics of the lesion such as firmness and mobility. Direct radiographs and computed tomography (CT) should be performed to assess the relationship of the mass to the bone. In osteochondroma cases, it has been reported that, in addition to radiographs, ultrasound can reveal soft-tissue changes and provide diagnostic capabilities comparable to CT.¹⁸ For osteochondromas located in uncommon sites, CT offers a significant diagnostic advantage.¹⁹

Plain radiographs and CT scans are generally insufficient for the differential diagnosis of BPOP and osteochondroma. MRI can also aid in distinguishing osteochondroma from BPOP radiologically. The radiologic distinction between the two lesions is typically based on whether the mass is confined to the periosteum of the originating bone or demonstrates medullary continuity.⁷ However, there are cases that show medullary continuity radiologically but are reported as BPOP on histopathological evaluation.²⁰ In our cases, we relied on imaging studies following a detailed medical history and physical examination. Although a diagnosis may be suggested through imaging, differentiating between these two lesions can be quite challenging. Interpretation of the imaging by experienced radiologists may provide additional guidance.

In cases where osteochondroma is suspected based on imaging methods and medical history, complete excision is performed with an excisional biopsy. Preoperative biopsy is particularly repeated in cases that develop recurrence to rule out malignancy. Histopathologically, osteochondromas consist of exophytic bone covered by a cartilage cap, containing chondrocytes arranged similarly to the epiphyseal growth plate and mature hyaline cartilage.⁴ In contrast, BPOP is described as a mass containing cartilage, bone, and spindle cells, characterized by irregular endochondral ossification with a partially irregular cartilage cap and a basophilic stroma (*blue bone*) found between the cartilage and bone.^{21,22} For these two masses, where macroscopic differentiation is not possible, histopathological diagnosis is essential. In our series, we provided a differential diagnosis through histopathological examination.

Conservative approaches and non-surgical treatments are indicated in the management of osteochondromas, among which retinoic acid receptor gamma agonists are emerging as a new treatment option.²³ Additionally, spontaneous resolution has been reported in asymptomatic cases.^{24,25} In asymptomatic young patients without skeletal maturity, non-surgical monitoring may be considered; however, in symptomatic cases, surgical treatment with marginal resection should be contemplated. For BPOP, surgical treatment is the primary management approach.²⁰

When considering surgical treatment for patients with exophytic bone outgrowths, two important factors must be taken into account; the risk of malignant transformation and the likelihood of recurrence. Malignant transformation is more commonly associated with osteochondromas, whereas recurrence is characteristic of BPOP.²⁶ The recurrence rates of BPOP should not be underestimated, with reported rates reaching up to 50%.^{13,27,28} Surgical outcomes for both osteochondroma and BPOP are generally satisfactory.^{20,29} In our series, preoperative and postoperative evaluations demonstrated significant improvement in clinical outcomes and high levels of patient satisfaction. Among our three cases of BPOP, recurrence occurred in one patient; however, even in this case, pain and clinical symptoms markedly improved compared with the preoperative condition.

Limitations

This study has several limitations. First, it is a retrospective study conducted at a single center. Another limitation is the rarity of these cases, which results in a small patient population. Finally, although there is no standardized

consensus for determining recurrence, a longer follow-up period in these cases could provide more meaningful information regarding recurrence development.

CONCLUSION

As a result, although cartilage-derived tumors other than enchondromas are uncommon, they can be detected in the upper extremity, particularly in the hand and wrist. This localization is atypical for osteochondroma, yet it occurs with a notable frequency. Cases of BPOP, which closely resemble osteochondromas, are rare and must be differentiated. Suspicion regarding these two distinct clinical entities can be raised by considering patient demographic data and imaging findings. Establishing an accurate differential diagnosis is important, as surgical treatment has demonstrated favorable clinical outcomes. Due to the high recurrence rate associated with BPOP, not only appropriate treatment but also long-term follow-up and patient counseling are essential.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was approved by the İnönü University Scientific Researches and Publication Ethics Committee (Approval Date: 05.11.2024, Decision No: 2024/6462).

Informed Consent

As this was a retrospective study, formal written informed consent was not required and was therefore not obtained.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Financial Disclosure

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Author Contributions

Concept: HUÖ, EE, OT, KE, HE, İBÇ; Design: HUÖ; KE; EE; Control: OT, İBÇ, HE; Resources: HUÖ, EE, OT, KE, HE, İBÇ; Materials: HUÖ, EE, OT, KE, HE, İBÇ; Data Collection and/or Processing: OT; İBÇ; HE; Analysis and/or Interpretation: EE; KE; HUÖ; Literature Review: HUÖ, EE, OT, KE, HE, İBÇ; Writing the Article: HUÖ; EE; KE; Critical Review: HUÖ, EE, OT, KE, HE, İBÇ.

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Association between bone mineral density and clinical-demographic characteristics in patients with post-stroke hemiplegia

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ABSTRACT

Aims: This study aimed to investigate the association between bone mineral density and clinical-demographic characteristics in patients with post-stroke hemiplegia and to evaluate potential factors associated with osteoporosis.

Methods: This retrospective, cross-sectional study included 80 patients with post-stroke hemiplegia who met the inclusion criteria and were followed at Physical Medicine and Rehabilitation Hospital between January 1, 2025, and October 1, 2025. Data were obtained through retrospective review of hospital information system records and patient files. Demographic and clinical characteristics were recorded. Bone mineral density (BMD) values were obtained from dual-energy X-Ray absorptiometry (DXA) measurements. Functional status and independence were assessed using the functional independence measure (FIM), while ambulation level was evaluated using the Functional Ambulation Scale (FAS). Serum calcium, parathyroid hormone (PTH), and vitamin D levels were also recorded. Associations between variables were analyzed using Spearman's correlation analysis, and statistical significance was set at $p < 0.05$.

Results: The mean age of the patients was 65.8 ± 9.5 years, and 56.2% were female. Ischemic stroke was present in 86.2% of patients, and the median stroke duration was 16 (1-288) months. A diagnosis of osteoporosis established after stroke but prior to DXA assessment was present in 16.2% of patients, and this rate increased to 37.5% when newly diagnosed cases were included. No significant difference was found in stroke duration between patients with and without osteoporosis ($p = 0.167$). No significant differences were observed in FIM, FAS, calcium, PTH, and vitamin D levels according to sex, osteoporosis status, comorbidities, or smoking/alcohol use (all $p > 0.05$). Only PTH levels were significantly lower in the hemorrhagic stroke group ($p = 0.046$), while vitamin D levels tended to be lower in the osteoporosis group ($p = 0.059$). A statistically significant, moderate, negative correlation was found between age and femoral neck bone mineral density ($r = -0.451$, $p < 0.001$).

Conclusion: Osteoporosis is common in patients with post-stroke hemiplegia, and age has a significant negative impact on femoral neck bone mineral density. However, functional status and ambulation level alone are insufficient to explain bone loss. These findings highlight the multifactorial nature of post-stroke osteoporosis and emphasize the clinical importance of early screening and preventive strategies in at-risk patients.

Keywords: Bone density, rehabilitation, vitamin D, risk factors, activities of daily living

INTRODUCTION

Stroke is a major cause of mortality and long-term disability worldwide and may result from ischemic or hemorrhagic mechanisms.^{1,2} It is commonly associated with hemiplegia, which leads to reduced mobility, functional impairment, and secondary musculoskeletal complications.³ These changes not only limit independence but also contribute to the development of various systemic complications in the post-stroke period.

Osteoporosis is a systemic skeletal disorder characterized by decreased bone mineral density (BMD) and deterioration of bone microarchitecture, leading to an increased risk of fractures.⁴ Epidemiological studies have reported a global prevalence of approximately 18%.⁵ Osteoporotic fractures,

particularly at the hip and vertebral levels, are associated with substantial morbidity, mortality, and reduced quality of life.⁶

In the post-stroke period, immobilization, muscle weakness, and reduced mechanical loading negatively influence bone metabolism, contributing to progressive bone loss, particularly at the femoral neck.^{7,8} Stroke patients also have an increased risk of falls due to balance impairment and motor dysfunction, further increasing the risk of osteoporotic fractures.^{9,10}

Osteoporosis and related fractures developing after stroke prolong the rehabilitation process, delay functional recovery, and impose an additional burden on the healthcare system.^{8,10} Therefore, early identification of post-stroke osteoporosis

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and determination of associated risk factors are of critical importance for both the prevention of fractures and the improvement of rehabilitation outcomes.

The aim of this study was to investigate the association between bone mineral density and clinical-demographic characteristics in patients with post-stroke hemiplegia and to evaluate potential factors associated with osteoporosis.

METHODS

Ethical approval for the study was obtained from the Ondokuz Mayıs University Clinical Researches Ethics Committee (Approval Date: 17.11.2025, Decision No: OMUKAEK 2025/538). The study was conducted in accordance with the Declaration of Helsinki.

In this retrospective, cross-sectional study, 80 patients who were followed at Physical Medicine and Rehabilitation Hospital between January 1, 2025, and October 1, 2025, with a diagnosis of post-stroke hemiplegia and who met the study criteria were included. Data were obtained through retrospective review of hospital information system records and patient files.

Patients aged 18 years and older who developed hemiplegia following ischemic or hemorrhagic stroke and had undergone BMD assessment during their treatment process were included in the study. Patients with a prior diagnosis or history of osteoporosis before stroke, those with severe additional neurological or orthopedic conditions (such as multiple sclerosis, Parkinson's disease, hip fracture, or spinal cord injury), a history of malignancy or bone metastasis, renal failure, hypercalcemia, or diseases significantly affecting vitamin D metabolism, as well as those with incomplete medical records, were excluded from the study. However, patients who were diagnosed with osteoporosis after stroke but before the dual-energy X-Ray absorptiometry (DXA) assessment were not excluded and were included in the analysis.

The demographic and clinical data of the patients were obtained from hospital information system records and patient files. Within this scope, age, sex, height, weight, type of stroke (ischemic/hemorrhagic), duration of stroke, hemiplegic side, occupation, and comorbidities were recorded.

BMD values of the patients were obtained from previously performed measurements using DXA.¹¹ In BMD assessments, femoral neck T-scores of the hemiplegic side were primarily considered; additionally, lumbar spine (L1-L4 and L2-L4) measurements were also recorded. T-score values of the relevant regions were used in the analysis. Osteoporosis was defined as a T-score of ≤ -2.5 in any of the measured regions.⁴

The patients' functional status, activities of daily living, and levels of independence were evaluated using the FIM scores available in the medical records.¹² FIM consists of 18 items covering motor and cognitive domains, including self-care, sphincter control, transfers, locomotion, communication, and social cognition. Each item is scored on a scale from 1 (complete dependence) to 7 (complete independence), with a total score ranging from 18 to 126. Higher scores indicate better functional independence. The Turkish version of the scale has been validated and shown to be reliable by Küçükdeveci et al.¹²

Ambulation level was assessed using the FAS scores recorded for each patient.¹³ This scale is scored from 0 to 5, where 0 indicates inability to walk and 5 indicates independent ambulation in all environments.

In addition, within the scope of biochemical parameters, serum calcium (mg/dl), parathyroid hormone (PTH) (pg/ml), and vitamin D (ng/ml) levels were recorded.

Statistical Analysis

The obtained data were analyzed using the SPSS 26.0 statistical software package. Descriptive variables were expressed as median, first and third quartiles, frequency, and percentage. The normality of continuous variables was assessed using the Shapiro-Wilk test. Variables with normal distribution were presented as mean \pm standard deviation (SD), while non-normally distributed variables were compared between independent groups using the Mann-Whitney U test. The relationships between variables were analyzed using Spearman's correlation analysis. Correlation coefficients were interpreted as weak for values between 0 and 0.29, moderate for values between 0.30 and 0.69, and strong for values between 0.70 and 1. Statistical significance was set at $p < 0.05$.

RESULTS

The sociodemographic characteristics of the patients are presented in **Table 1**. The mean age of the study population was 65.8 ± 9.5 years, and the majority were female. The clinical and disease-related characteristics are summarized in **Table 2**, showing that ischemic stroke was the predominant subtype.

Table 1. Sociodemographic characteristics of the patients

Variables	n (%)
Age (years), mean \pm SD	65.8 \pm 9.5
Sex	
Male	35 (43.8)
Female	45 (56.2)
Education level	
Illiterate	16 (20.0)
Primary school	40 (50.0)
Middle school	9 (11.2)
High school	11 (13.8)
University or higher	4 (5.0)
Marital status	
Married	75 (93.8)
Single	5 (6.2)
Employment status/occupation	
Civil servant	2 (2.5)
Worker	26 (32.5)
Retired	12 (15.0)
Housewife	40 (50.0)
Total	80 (100.0)
SD: Standard deviation	

A diagnosis of osteoporosis established after stroke but prior to the DXA assessment was present in 16.2% of the patients, and this rate increased to 37.5% when newly diagnosed cases were

Variables	n (%)
Stroke type	
Ischemic	69 (86.2)
Hemorrhagic	11 (13.8)
Hemiplegic side	
Right	42 (52.5)
Left	38 (47.5)
Previous diagnosis of osteoporosis	
Yes	13 (16.2)
No	67 (83.8)
Osteoporosis diagnosis (including newly diagnosed cases)	
Yes	30 (37.5)
No	50 (62.5)
Family history of osteoporosis	
Yes	7 (8.8)
No	73 (91.2)
History of fragility fracture	
Yes	14 (17.5)
No	66 (82.5)
Receiving osteoporosis treatment	
Yes	13 (16.2)
No	67 (83.8)
Total	80 (100.0)

included. Among patients diagnosed with osteoporosis prior to the DXA assessment, the median duration of diagnosis was 1 (0.5-4) years. The rate of osteoporosis treatment was relatively low. Additional clinical characteristics related to osteoporosis are presented in **Table 2**.

In the evaluation of functional independence, the median FIM score was 74.50 (Q1: 55.25-Q3: 98.25). The median FAS score was 3.00 (Q1: 2.00-Q3: 4.00).

Regarding biochemical parameters, the median calcium level was 9.70 mg/dl (Q1: 9.39-Q3: 10.03), the median parathyroid hormone (PTH) level was 31.00 pg/ml (Q1: 20.00-Q3: 51.99), and the median vitamin D level was 18.50 ng/ml (Q1: 13.00-Q3: 24.24).

When newly diagnosed cases were included, the median stroke duration was 18 (Q1: 9.5-Q3: 30.7) months in patients with osteoporosis and 14.5 (Q1: 3-Q3: 26) months in those without osteoporosis. No statistically significant difference was found between the groups in terms of stroke duration (p=0.167).

In subgroup analyses, no significant differences were observed in FIM, FAS, calcium, PTH, and vitamin D levels according to sex or osteoporosis status (all p>0.05). However, PTH levels were significantly lower in the hemorrhagic stroke group (median: 25 pg/ml vs. 34.4 pg/ml, p=0.046). In analyses including newly diagnosed cases, vitamin D levels were lower in the osteoporosis group, although the difference did not reach statistical significance (p=0.059). No statistically significant differences were found between comorbidities, smoking or alcohol use, and scale scores or biochemical parameters (all p>0.05). The detailed results of the subgroup analyses are presented in **Table 3**.

When patients with and without osteoporosis were compared, the median BMI values were 28.2 (Q1: 24.1-Q3: 32.1) and 29.0 (Q1: 27.0-Q3: 31.0), respectively. Although BMI was higher in the non-osteoporotic group, this difference was not statistically significant (p=0.178).

In Spearman correlation analysis, a statistically significant, strong, and positive correlation was found between FAS and FIM (r=0.725, p<0.001) (**Table 4**).

Among BMD measurements, statistically significant positive correlations were observed between the femoral neck and L1-L4 (r=0.608, p<0.001), between L1-L4 and L2-L4 (r=0.949, p<0.001), and between the femoral neck and L2-L4 (r=0.572,

Variables	Functional independence measure score	Functional Ambulation Scale score	Calcium (mg/dl)	Parathyroid hormone (pg/ml)	Vitamin D (ng/ml)
			Median (Q1-Q3)		
Sex					
Male	79 (60-100)	3 (2-4)	9.7 (9.5-9.9)	29.1 (17.9-52.6)	20.3 (13-30)
Female	72 (48-95.5)	3 (2-4)	9.6 (9.3-10.1)	33.4 (21.9-50.9)	16.8 (12.4-20.8)
p-value*	0.367	0.877	0.981	0.734	0.135
Stroke type					
Ischemic	74 (48-106)	3 (2-4)	9.6 (9.3-10)	34.4 (21-54.4)	18 (12.4-22.1)
Hemorrhagic	78 (19-89)	3 (2-4)	9.7 (9.3-10)	25 (12-33.6)	20.4 (14.6-44)
p*	0.630	0.556	0.839	0.046	0.133
Previous osteoporosis diagnosis					
Yes	84 (53.5-95.5)	3 (1.5-4.5)	9.6 (9.3-9.9)	25.2 (21.9-42.8)	18 (12.1-22.7)
No	74 (55-100)	3 (2-4)	9.7 (9.4-10.0)	33.6 (18.2-54.3)	19 (13.2-26.1)
p-value*	0.819	0.601	0.583	0.300	0.548
Osteoporosis diagnosis (including newly diagnosed cases)					
Yes	74.5 (47.5-97)	2.5 (1.7-4)	9.6 (9.2-9.9)	29 (19.5-45.3)	16.2 (12.5-20.1)
No	75 (56-99.2)	3 (2-4)	9.7 (9.4-10.1)	34 (19.4-55)	20 (13.3-28.6)
p-value*	0.945	0.500	0.109	0.518	0.059

*Mann-Whitney U test

Table 4. Correlations between functional scores, stroke duration, DXA T-scores, and age

Variables	Functional independence measure score	Functional Ambulation Scale score	Stroke duration (months)	Lumbar spine (L1-L4) T-score	Lumbar spine (L2-L4) T-score	Femoral neck T-score	Age (years)
Functional independence measure score							
r	1						
p	.						
Functional Ambulation Scale score							
r	.725	1					
p	<0.001	.					
Stroke duration (months)							
r	.013	.143	1				
p	.909	.206	.				
Lumbar spine (L1-L4) T-score							
r	-.014	-.001	-.106	1			
p	.905	.995	.349	.			
Lumbar spine (L2-L4) T-score							
r	-.023	.038	-.059	.949	1		
p	.842	.738	.606	<0.001	.		
Femoral neck T-score							
r	.087	.051	-.157	.608	.572	1	
p	.445	.651	.165	<0.001	<0.001	.	
Age (years)							
r	-.134	-.118	.049	-.239	-.232	-.451	1
p	.236	.298	.668	.033	.039	<0.001	.

r: Correlation coefficient

p<0.001). The correlations were strong between L1-L4 and L2-L4, and moderate between the femoral neck and L2-L4 (Table 4).

Age showed statistically significant negative correlations with L1-L4 (r=-0.239, p=0.033) and L2-L4 (r=-0.232, p=0.039), both at a weak level, while a moderate negative correlation was observed with the femoral neck (r=-0.451, p<0.001) (Table 4).

DISCUSSION

In this study, the prevalence of osteoporosis in post-stroke hemiplegic patients was 37.5% when newly diagnosed cases were included. Bone mineral density decreased with increasing age, particularly at the femoral neck. However, no significant association was observed between osteoporosis and functional independence, ambulation level, or biochemical parameters. These findings are consistent with previous studies suggesting that post-stroke bone loss may be more pronounced in the paretic extremity, especially at the femoral neck.^{14,15}

The prevalence of osteoporosis observed in our study is higher than that expected in the general population, supporting the notion that post-stroke patients constitute a specific high-risk group in terms of bone health. Watanabe reported that approximately 40% of subacute stroke patients evaluated at rehabilitation admission had osteoporosis, a finding that is consistent with our results.¹⁶ Furthermore, previous reviews have emphasized that post-stroke bone loss is often detected only through DXA assessment or after fracture occurrence, and that routine screening remains insufficient.^{8,15} This may partly explain the higher prevalence of osteoporosis (37.5%)

observed in our study when newly diagnosed cases were included.

A negative association between age and BMD was observed, particularly at the femoral neck, where the correlation was moderate and statistically significant. This finding is consistent with both general osteoporosis literature and studies investigating post-stroke bone loss.^{17,18} Age-related bone loss and reduced mechanical loading after stroke may contribute to this process.

In our study, despite the expected higher prevalence of osteoporosis in women, no significant differences were observed between sexes in terms of FIM, FAS, calcium, PTH, and vitamin D levels. This finding is consistent with previous studies suggesting that post-stroke bone loss is more closely related to immobilization and reduced mechanical loading than to sex.^{15,19} Although Watanabe reported an association between BMD and both age and sex, bone resorption markers were also found to be related to disability level.¹⁶ The absence of a significant sex-related difference in our study may therefore be attributed to the effects of post-stroke immobilization and sample characteristics.

When patients with and without osteoporosis were compared, BMI values were slightly higher in the non-osteoporotic group; however, this difference was not statistically significant (p=0.178). Although higher BMI has been suggested as a potential protective factor against osteoporosis, with previous studies demonstrating a positive association between body weight and BMD,¹⁸ our findings did not confirm this relationship. Similarly, PTH levels were lower in the hemorrhagic stroke group, while no other

significant differences were observed according to stroke type. This finding may indicate that bone metabolism in post-stroke patients is more strongly influenced by immobilization and reduced mechanical loading than by stroke subtype.^{15,19} However, given the limited number of patients in the hemorrhagic stroke group, this result should be interpreted with caution. In addition, vitamin D levels tended to be lower in the osteoporosis group, although the difference did not reach statistical significance ($p=0.059$). This trend may still be clinically relevant, as factors such as reduced sun exposure, malnutrition, immobilization, and disturbances in vitamin D metabolism have been reported to contribute to post-stroke bone loss.^{15,19}

In our study, no significant correlation was found between FIM and FAS scores and DXA T-scores. This finding differs from previous studies reporting an association between functional status and bone health. Schnitzer et al.²⁰ reported lower BMD in patients with impaired ambulation, particularly on the paretic side, while Yavuzer et al.²¹ demonstrated greater bone loss in patients with increased motor impairment and functional dependence. However, FIM and FAS reflect current functional status, whereas bone loss represents the cumulative effect of reduced mechanical loading over time, which may explain the lack of a significant association. In addition, variability in stroke duration and the absence of standardized timing of DXA assessments may have further influenced this finding.

A strong positive correlation between FAS and FIM observed in our study indicates internal consistency among functional measures. However, the lack of association with BMD suggests that bone loss cannot be explained solely by ambulatory capacity. In post-stroke osteoporosis, multiple factors such as reduced mechanical loading, muscle changes, and metabolic influences may contribute to bone loss.^{15,19} These findings indicate that functional status alone may not adequately reflect bone health, and relying solely on functional assessments in clinical practice may be insufficient.

Although a positive correlation was observed between lumbar spine measurements and the femoral neck, the most pronounced negative association with age was identified at the femoral neck. This finding is consistent with previous studies reporting that post-stroke bone loss is more prominent at the femoral neck, while changes in the lumbar spine are less evident.^{14,21} These findings suggest that the femoral neck may be a more sensitive region for detecting post-stroke bone loss.

No significant association was found between stroke duration and osteoporosis. Previous studies have shown that bone loss is most rapid in the early months following stroke and may continue at a slower rate thereafter.^{14,15} However, the wide variability in stroke duration and the cross-sectional design of our study may have limited the ability to detect this temporal relationship. In addition, the lack of standardized timing of DXA measurements may have further influenced this finding.

One of the key clinical implications of this study is that bone loss in post-stroke hemiplegic patients should not be considered only after the occurrence of fractures. Previous studies have emphasized that the use of DXA in post-stroke patients remains insufficient and that osteoporosis is frequently underdiagnosed in the absence of routine screening.⁸ Schnitzer et al.²⁰ highlighted the importance of screening in patients with limited ambulation, while Lee et

al.²² demonstrated that low femoral BMD in acute ischemic stroke may be associated with poor functional outcomes.

In our study, the prevalence of osteoporosis was 37.5%, supporting the notion that post-stroke patients constitute a high-risk group. These findings suggest that bone health in hemiplegic stroke patients may require more systematic evaluation, even in the absence of overt clinical symptoms.

Limitations

This study has several important limitations. First, due to its retrospective and cross-sectional design, causal relationships cannot be established. The data were obtained from hospital information systems and patient records; therefore, the findings are dependent on the accuracy and completeness of these records.

Second, only patients who underwent DXA as part of routine clinical practice were included; therefore, the sample may not represent all post-stroke hemiplegic patients but rather a selected group requiring evaluation of bone health, which may have introduced selection bias.

Third, bilateral femoral neck measurements were not performed, as DXA assessments are not routinely conducted bilaterally in standard clinical practice, and the retrospective design limited the availability of such data. Therefore, only measurements from the paretic side were included in the analysis, and direct comparison between the paretic and non-paretic sides could not be performed.

Fourth, several variables that may influence bone health, such as physical activity level, daily load-bearing, sun exposure, nutritional status, menopausal status, muscle mass, and medication use, could not be systematically evaluated.

Finally, the sample size may have been insufficient for certain subgroup analyses, which may have limited the statistical power, particularly for borderline findings such as vitamin D levels.

CONCLUSION

As a result, osteoporosis is a common and clinically significant condition in post-stroke hemiplegic patients. The findings of this study demonstrate a high prevalence of osteoporosis and indicate that age has a negative impact on BMD, particularly at the femoral neck. In contrast, functional independence and ambulation level alone appear insufficient to explain bone loss. Our results suggest that post-stroke osteoporosis is a multifactorial process and that bone health in hemiplegic patients should be evaluated not only after the occurrence of fractures but also during routine clinical follow-up. Early screening and appropriate preventive strategies, particularly in older patients and those at increased clinical risk, may contribute to reducing long-term fracture risk. Future prospective studies with larger sample sizes, incorporating standardized timing of BMD assessments and comprehensive evaluation of factors influencing bone metabolism, are warranted to further elucidate the mechanisms underlying post-stroke osteoporosis.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was approved by the Ondokuz Mayıs University Clinical Researches Ethics Committee (Approval Date: 17.11.2025, Decision No: OMUKAEK 2025/538).

Informed Consent

As this was a retrospective study, formal written informed consent was not required and was therefore not obtained.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Financial Disclosure

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Author Contributions

Concept: ZC, MAK; Design: ZC, MAK; Control: ZC, MAK; Resources: ZC, MAK; Materials: ZC, MAK; Data Collection and/or Processing: ZC, MAK; Analysis and/or Interpretation: ZC; Literature Review: ZC, MAK; Writing the Article: ZC; Critical Review: MAK.

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Clinical differences between patients with and without electrophysiological evidence of carpal tunnel syndrome*

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ABSTRACT

Aims: It was aimed to determine the clinical differences between patients with and without electrophysiological evidence of carpal tunnel syndrome (CTS).

Methods: Patients who were clinically diagnosed with CTS were included in this retrospective cohort study. Median nerve compound muscle action potential and compound nerve action potential of the patients were analyzed. Clinically diagnosed CTS patients were divided into two groups according to the results of nerve conduction studies as patients with and without electrophysiological evidence of CTS. At the same time the age, body-mass index (BMI), duration of symptoms and comorbidity of all the patients were recorded.

Results: 60 patients clinically diagnosed with CTS (52 women and 8 men) were included in the study. Electrophysiological evidence of CTS was present in 40 patients (66.7%) and absent in 20 (33.3%). Patients with electrophysiological evidence of carpal tunnel syndrome were older ($p=0.021$) and had higher body weight and BMI (both $p<0.001$) compared to those without such findings. Symptom duration was also longer in this group ($p<0.001$), while no significant difference was observed in height ($p=0.654$).

Conclusion: Electrophysiological abnormalities are more often detected in CTS patients with longer symptom duration and higher BMI. Older age is also associated with the presence of electrophysiological abnormalities.

Keywords: Body-mass index, carpal tunnel syndrome, electrophysiology, nerve conduction studies

*This study has previously been presented at 20th International Eastern Mediterranean Family Medicine Congress-2021.

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common entrapment mononeuropathy. Patients typically present with paresthesia in the first three digits. In some cases, neuropathic pain may develop, and weakness or atrophy of the hand muscles may also occur.^{1,2} Early diagnosis, appropriate treatment, and prevention of progression are therefore important.

Clinical evaluation and electrophysiological studies are commonly used in the diagnosis of CTS. Electrophysiological testing plays a key role in confirming the diagnosis, assessing severity, and supporting the differential diagnosis.^{3,4} However, CTS cannot be confirmed electrophysiologically in all patients. In some individuals with strong clinical suspicion, electrophysiological findings may remain normal.^{2,5} Given this background, the present study examined whether CTS could be identified electrophysiologically in patients with a clinical diagnosis of CTS and aimed to determine the clinical differences between patients with and without electrophysiological evidence of CTS.

METHODS

Subjects

Patients aged 18 years or older who were clinically diagnosed with CTS between March 2012 and May 2013 at the Department of Neurology, Çukurova University Faculty of Medicine were included in this retrospective study. Ethical approval was obtained from the Çukurova University Faculty of Medicine Non-interventional Clinical Researches Ethics Committee (Approval Date: 09.02.2012, Decision No: 5/28). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. A clinical diagnosis of CTS was established when at least one of the following was present: (1) paresthesia in the first three digits, more pronounced at night; (2) sensory complaints involving the first three digits; or (3) sensory abnormalities in the first three digits on neurological examination; or (4) nocturnal worsening of symptoms affecting the same distribution. These findings could be accompanied by weakness or atrophy of median nerve-innervated hand muscles. Patients were excluded if they

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had clinical or electrophysiological findings consistent with cervical radiculopathy or brachial plexopathy, or a known neurodegenerative disease. Patients were categorized into two groups based on whether electrophysiological findings consistent with CTS were present.

Electrophysiological Tests

Nerve conduction studies were performed using a Medelec Synergy EMG device. For sensory and motor studies, filter settings were 20 Hz-2 kHz and 20 Hz-10 kHz, respectively. Recordings were obtained with surface electrodes. Studies were conducted when extremity temperature exceeded 32°C; otherwise, the limb was warmed. Compound muscle action potentials (CMAPs) were recorded from the abductor pollicis brevis muscle. In motor studies, the distance between the stimulation site at the wrist and the recording electrode was 8 cm. Sensory nerve action potentials were recorded antidromically from the second digit-wrist segment. Sensory conduction velocity was calculated using onset latency. Electrophysiological CTS was defined by the presence of any of the following: (1) median sensory conduction velocity <50 m/s in the second digit-wrist segment; (2) median sensory conduction velocity <50 m/s in the same segment together with distal CMAP latency >4 ms; or (3) absent median sensory response in the second digit-wrist segment together with distal CMAP latency >4 ms.

Statistical Analysis

The Shapiro-Wilk test was used to determine the distribution of the data. Pearson’s Chi-squared test was used to analyze categorical variables. Mann-Whitney U test was used in group comparisons. Mean±standard deviation (SD) and median were calculated for descriptive statistics. Post hoc power analysis was performed for the variables that differed significantly between groups, including age, body weight, BMI, and symptom duration, using the observed between-group differences at an alpha level of 0.05. If p-value was <0.05, it was considered statistically significant. Statistical Package for the Social Sciences (SPSS IBM Corp; Armonk, NY, USA) 22.0 was used to perform the statistical analysis.

RESULTS

The study included 60 patients with clinically diagnosed CTS (52 women and 8 men). Of these, 55 had bilateral involvement and 5 had unilateral involvement. The mean age was 51.2±12.6 years (range, 22-80), mean height was 165.1±5.9 cm (151-183), mean weight was 80.4±14.5 kg (51-128), and mean body-mass index (BMI) was 28.9±5.3 kg/m² (18-48). The mean duration of symptoms was 16.8±11.7 months (2-60). Electrophysiological evidence of CTS was present in 40 patients (66.7%) and absent in 20 (33.3%). Bilateral

CTS was identified electrophysiologically in 23 patients, while 15 had right-sided CTS and 2 had left-sided CTS. Demographic characteristics of patients with and without electrophysiological CTS are compared in **Table**. Patients with electrophysiological evidence of CTS were significantly older than those without (p=0.021). They also showed higher body weight and BMI (both p<0.001), along with a longer duration of symptoms (p<0.001), whereas height did not differ between the groups (p=0.654). Post hoc power analysis showed adequate statistical power for the significant between-group differences in age, body weight, BMI, and symptom duration. Among patients with electrophysiological CTS, 8 had diabetes mellitus and 1 had thyroid disease, whereas none of those without electrophysiological CTS had diabetes mellitus or thyroid disease (**Figure**).

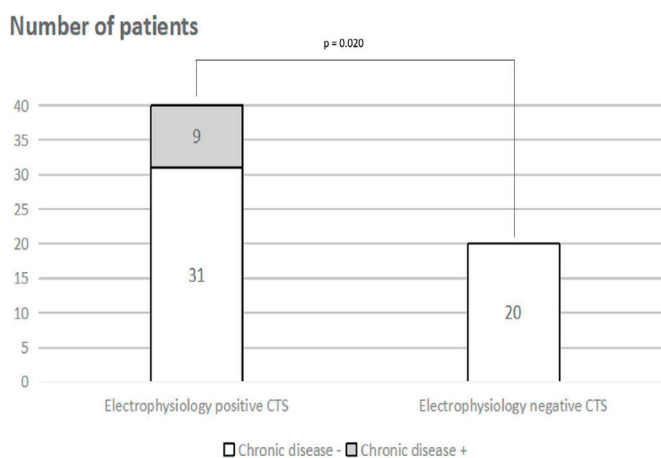


Figure. Number of patients

DISCUSSION

This study showed that approximately one-third of patients with a clinical suspicion of CTS had normal electrophysiological findings. This observation indicates a potential mismatch between clinical assessment and electrophysiological results.^{5,6} The longer symptom duration in patients with electrophysiological confirmation suggests that these tests may remain normal early in the disease course.

Patients with electrophysiological evidence of CTS were older and had higher body weight and BMI. Increased body mass may contribute to greater mechanical stress on the median nerve, thereby increasing susceptibility to CTS. In addition, variations in age, weight, and BMI may promote endoneural edema and microvascular compromise, which can further facilitate the development of CTS. These findings are in line with previous reports identifying obesity and older age as important risk factors for CTS.⁷

Table. Demographic characteristics of patients with and without electrophysiological evidence of carpal tunnel syndrome

Demographic characteristics	Patients without electrophysiological evidence of CTS (n=20) Median (min-max)	Patients with electrophysiological evidence of CTS (n=40) Median (min-max)	p-value
Age	45 (22-75)	54 (29-80)	0.021
Size (cm)	165 (154-173)	164 (151-183)	0.654
Weight (kg)	66 (51-86)	85 (66-128)	<0.001
BMI	24 (18-30)	30 (25-48)	<0.001
Duration of complaint (month)	6 (2-25)	24 (6-60)	<0.001

CTS: Carpal tunnel syndrome, BMI: Body-mass index

Symptom duration was longer in patients with electrophysiological evidence of CTS than in those with a clinical diagnosis but no electrophysiological confirmation.⁸ This pattern suggests that demyelination and axonal involvement become more apparent over time. Electrophysiological findings may remain normal in patients with a short duration of symptoms. In cases with strong clinical suspicion, close follow-up and repeat testing, when appropriate, may be warranted. Additionally, the presence of diabetes mellitus and thyroid disease in patients with electrophysiological evidence of CTS is noteworthy.⁹⁻¹¹ Neuropathies, including CTS, are well recognized in diabetes. In this setting, endoneural microvascular ischemia, endoneural edema, and alterations in connective tissue may increase susceptibility to nerve compression.¹² In the present study, diabetes was present in 20% of patients with electrophysiological CTS, supporting a possible association between the two conditions. CTS may also occur in the context of thyroid disease and should be considered in these patients.^{10,13}

Electrophysiological studies play a central role in the diagnosis, assessment of severity, and differential diagnosis of CTS.^{3,9} However, normal findings may be encountered in some patients, which represents an important limitation.¹⁴ This may reflect the inability of routine nerve conduction studies to assess small fiber involvement.^{5,15,16} For this reason, electrophysiological results should be interpreted in conjunction with clinical findings. Moreover, overlapping symptom profiles in certain disorders may contribute to underdiagnosis or misinterpretation of CTS, even when objective findings are limited.¹⁴

Ultrasonographic evaluation, which has been shown to correlate with clinical findings in CTS in certain patient populations, may provide complementary information beyond electrophysiological studies.¹⁴

Limitations

This study has several limitations. First, its retrospective design may have affected patient selection. The relatively small sample size and single-center setting may limit the generalizability of the findings. In addition, conventional nerve conduction studies may not detect mild or early cases of CTS, which could have led to underestimation in some patients. Other diagnostic approaches, such as ultrasonography or small fiber assessment, were not used. Finally, the absence of longitudinal follow-up does not allow assessment of whether patients with normal electrophysiological findings later developed detectable abnormalities.

CONCLUSION

Electrophysiological studies may not detect CTS in all patients, particularly in those who are younger, have a shorter duration of symptoms, and a lower BMI. These findings suggest that such tests may be less sensitive early in the course of the condition. Clinical assessment therefore remains essential, and electrophysiological results should be interpreted together with the overall clinical picture rather than relied upon alone when making the diagnosis.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was approved by the Çukurova University Faculty of Medicine Non-interventional Clinical Researches Ethics Committee (Approval Date: 09.02.2012, Decision No: 5/28).

Informed Consent-Non-Retrospective Studies

As this was a retrospective study, formal written informed consent was not required and was therefore not obtained.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Financial Disclosure

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Author Contributions

Concept: ŞB, ŞFR; Design: ŞB; Control: ŞB, ŞFR; Resources: ŞB, ŞFR; Materials: ŞB, ŞFR; Data Collection and/or Processing: ŞB; Analysis and/or Interpretation: ŞB; Literature Review: ŞB; Writing the Article: ŞB, ŞFR; Critical Review: ŞB.

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Delayed cage retropulsion 15 years after posterior lumbar interbody fusion: a case report

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ABSTRACT

Cage retropulsion is a rare complication of lumbar interbody fusion and is typically reported in the early postoperative period. We present a case of delayed symptomatic cage retropulsion occurring 15 years after posterior lumbar interbody fusion (PLIF). The patient presented with progressive low back pain and radicular symptoms. Radiological evaluation demonstrated posterior migration of the intervertebral cage at the operated level. There was no history of early postoperative complications. Delayed retropulsion was considered to be related to long-term biomechanical changes and progressive loss of bone mineral density. This case emphasizes that cage retropulsion may occur many years after PLIF and should be considered in patients with late-onset symptoms following lumbar fusion surgery.

Keywords: Spinal fusion, posterior lumbar interbody fusion, tomography, X-Ray computed, retropulsion

INTRODUCTION

Posterior lumbar interbody fusion (PLIF) is a surgical technique in which a cage is inserted into the intervertebral space via a posterior approach. The procedure is designed to address segmental instability, restore disc height and foraminal dimensions, and achieve solid spinal fusion. Indications include degenerative disc disease, spondylolisthesis, recurrent disc herniation with associated instability, spinal stenosis with instability, traumatic disc injury, and stabilization following infection or tumor resection. PLIF is generally contraindicated in patients with severe osteoporosis or in cases requiring anterior column support due to significant spinal deformity.^{1,2}

PLIF offers several advantages, including increased foraminal height, improved mechanical stability, and the ability to achieve posterior decompression and fusion in a single surgical procedure. However, it is associated with potential complications such as dural injury, nerve root traction, epidural fibrosis, and cage retropulsion, particularly in patients with osteoporosis. Although PLIF aims to promote spinal fusion, the cage may become displaced for various reasons, especially during the early postoperative period. Such displacement can lead to a range of clinical symptoms and complications.³⁻⁵

This case report aims to describe a patient in whom the interbody fusion cage completely migrated posteriorly following a PLIF procedure performed approximately 15 years ago.

CASE

A 68-year-old female patient presented with progressively worsening severe low back and bilateral leg pain, numbness, difficulty walking more than 50 meters, and difficulty standing, with a duration of four months. She had not benefited from conservative managements. Her medical history revealed that she had undergone decompression and stabilization surgery for lumbar spinal stenosis approximately 15 years earlier. There was no history of trauma, such as a fall, and she had no sphincter dysfunction. Her medical history was notable for coronary artery bypass surgery three years ago, hysterectomy and cholecystectomy approximately 20 years ago, and surgical fixation of a right femur fracture three years ago. She also had a history of hypertension and goiter. Neurological examination revealed positive straight leg raise, Laseque, and femoral stretch tests. Sensory, motor, and reflex examinations were normal.

Due to the presence of spinal instrumentation in the patient, plain radiographs and computed tomography examinations of lumbar spine were performed. These studies demonstrated complete displacement of the PLIF material from its original position (**Figure 1, 2**). Magnetic resonance imaging did not reveal any additional compressive pathology that could explain the clinical findings, such as adjacent segment disease. The patient was operated on under general anesthesia. Through a left-sided approach, the existing laminectomy defect was enlarged to gain access to the PEEK (polyetheretherketone), non-cutting cage. The cage was

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removed without any complications, such as cerebrospinal fluid leakage or nerve root injury (Figure 3). The patient is being followed up with uneventful clinical outcomes.

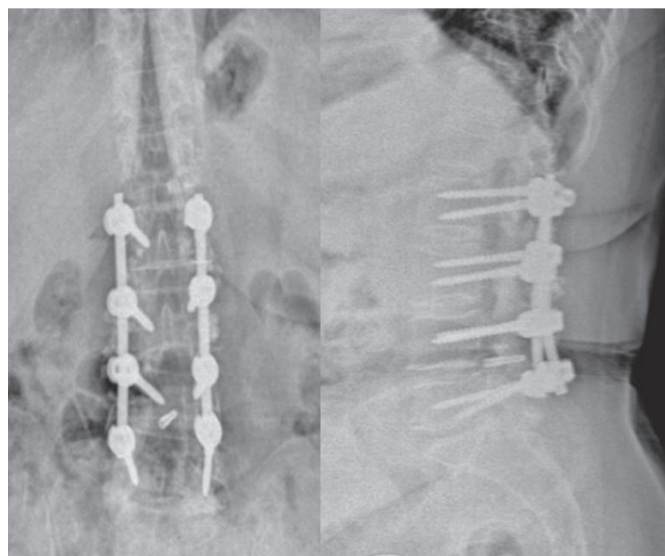


Figure 1. AP and lateral plain X-Ray of lumbar spine showing retropulsion of cage

AP: Anteroposterior

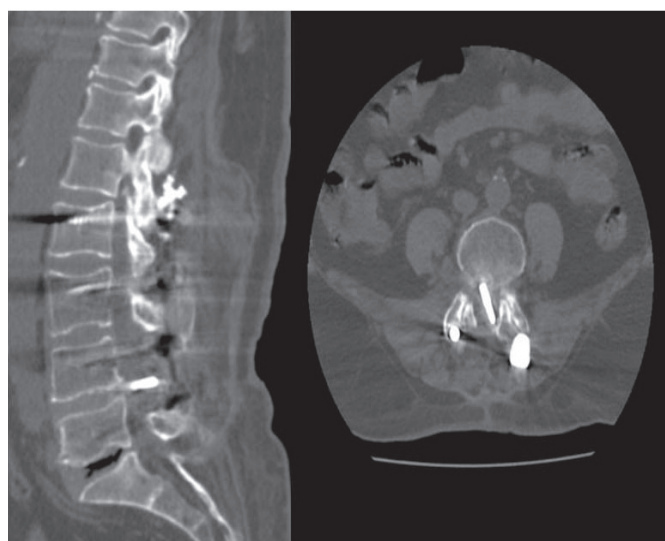


Figure 2. Computed tomography imaging on sagittal and axial planes showing retropulsion of cage

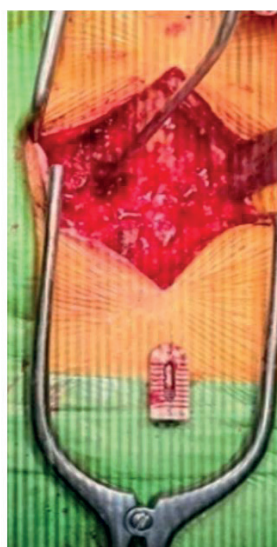


Figure 3. Intraoperative photograph demonstrating the removed interbody cage

DISCUSSION

PLIF has been widely used for many years in the surgical treatment of degenerative lumbar spine diseases. Cage retropulsion is a rare but clinically significant complication of PLIF surgery and most commonly occurs in the early postoperative period. In the literature, the majority of cases have been reported within the first 3-12 months after surgery, and several studies have analyzed risk factors and incidence rates of this complication. For example, large retrospective case series have documented cage retropulsion occurring predominantly in the early postoperative period following PLIF procedures.⁶⁻⁹ This case report is noteworthy because the cage retropulsion became symptomatic 15 years after surgery, highlighting both its rarity and exceptionally late presentation. The exceptionally late onset of symptomatic retropulsion far beyond the typical early postoperative period underscores the need for long-term vigilance in patients with a history of lumbar interbody fusion.

Early-onset cage retropulsion following PLIF is predominantly attributed to inadequate stabilization, end-plate injury, inappropriate cage size or positioning, and osteoporosis. These factors compromise the immediate mechanical environment required for stable interbody fusion and increase the risk of posterior migration of the cage.^{10,11} In contrast, the pathophysiology of late-onset cases is more closely related to gradual biomechanical changes that occur over time. Long-standing pseudoarthrosis, progressive bone resorption, advancing osteoporosis, and adjacent segment degeneration can undermine the initial postoperative stability and create conditions conducive to posterior migration of a cage that was radiographically stable in the early postoperative period. Such chronic alterations may reduce the structural support around the fusion site, facilitating delayed retropulsion.^{12,13}

The symptoms that developed long after surgery in this patient are most likely attributable to progressive loss of bone mineral density and weakening of the contact between the end plates and the cage surface. In particular, posteriorly positioned cages are known to be disadvantaged against long-term axial loading, which may predispose them to migration or retropulsion.^{6,14} These factors may lead to a gradual increase in posteriorly directed forces over time, resulting in late-onset retropulsion.

A review of the existing literature indicates that cases of cage retropulsion following PLIF are predominantly reported in the early or late-early postoperative period, with the reported follow-up duration generally limited to one year. In contrast, our comprehensive literature review did not identify any cases of cage retropulsion occurring beyond one year postoperatively. In this situation, patient gradually develops recurrent low back pain, radiculopathy, or neurological deterioration over time. This clinical pattern highlights the critical importance of maintaining long-term biomechanical stability following spinal fusion surgery.

This presenting case demonstrates that cage retropulsion following PLIF is not solely an early postoperative complication but may also manifest clinically in the very late postoperative period. Taken together, these findings underscore that, particularly in younger patients who undergo spinal surgery and will be exposed to lifelong spinal

loading, preservation of long-term bone health is as critical as the surgical technique itself.

CONCLUSION

As a result, cage retropulsion should be considered in the differential diagnosis when new-onset low back pain or radicular symptoms occur during long-term follow-up after PLIF application, even many years after surgery. This case highlights the clinical relevance of very late postoperative complications and underscores the need for prolonged clinical and radiological surveillance.

ETHICAL DECLARATIONS

Informed Consent

Written informed consent was obtained from the patient included in this report. Signed consent forms are retained by the authors and are available upon request.

Peer Review Process

This report underwent external peer review.

Conflict of Interest

The authors declare no conflicts of interest.

Financial Disclosure

This case report did not receive any financial support.

Author Contributions

Concept: HA; Design: HA, SÖ; Control: HA, SÖ; Resources: HA, SÖ, EA; Materials: HA, EA; Data Collection and/or Processing: HA, SÖ, EA; Analysis and/or Interpretation: HA, SÖ; Literature Review: SÖ, EA; Writing the Article: SÖ, EA; Critical Review: HA, EA.

Acknowledgments

We thank the patient for her cooperation and consent to share the clinical details for this report.

Data Availability

All relevant data supporting the findings of this case report are included in the manuscript. Additional data can be made available upon request.

Artificial Intelligence Usage Statement

ChatGPT was used to assist with English language translation.

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Commentary on the “comparative effectiveness of medium- and low-intensity extracorporeal shock wave therapy for plantar fasciitis”

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Dear Editor,

We read with great interest the article by Kılıc et al.¹ titled “Comparison of the effectiveness of medium- and low-intensity extracorporeal shock wave therapy in patients with plantar fasciitis.” The authors should be commended for addressing the clinically relevant and ongoing debate regarding optimal ESWT energy levels in the management of plantar fasciitis.

The study was impressively put together. By using a randomized controlled design and including a placebo group, the authors gave us results we can actually rely on. I also appreciated that they didn’t just look at pain scores (VAS); by using tools like the Foot Function Index and the Nottingham Health Profile, they captured how this treatment affects a person’s overall quality of life and daily movement.¹

Seeing that both medium- and low-intensity therapy led to real improvements is encouraging. It’s a meaningful contribution to the field that helps us feel more confident in the rehab plans we design for our patients. However, several methodological and interpretative aspects merit further discussion.

First, although the authors initially randomized 60 participants, a relatively high dropout rate resulted in final group sizes of 14, 17, and 11 participants. This attrition substantially reduced statistical power, as acknowledged by the reported post-hoc power of approximately 58%. Consequently, the absence of significant between-group differences—particularly between low- and medium-intensity ESWT—may partly reflect insufficient power rather than true equivalence.

Second, all groups, including the placebo group, received cold pack application and a standardized exercise program. While ethically appropriate, this co-intervention likely contributed

to the significant improvements observed in the placebo group across pain, function, and quality-of-life measures. As a result, isolating the independent effect of ESWT intensity becomes challenging, and the strong placebo response should be interpreted with caution.

Additionally, effect sizes and confidence intervals were not reported. Reliance solely on p-values limits understanding of the magnitude and precision of treatment effects. The absence of minimal clinically important difference (MCID) thresholds also restricts the interpretation of whether statistically significant changes were clinically meaningful.²

Despite these limitations, the study contributes valuable data suggesting that both low- and medium-intensity ESWT are beneficial for short- to mid-term management of PF, with no clear superiority of one intensity over the other. This information is particularly useful for clinicians when balancing treatment efficacy, patient tolerance, and resource availability.

Overall, this study provides reassuring evidence that both low- and medium-intensity ESWT can produce meaningful short-term improvements in pain and function in plantar fasciitis. The authors’ transparent reporting and acknowledgment of limitations lay a strong foundation for future adequately powered trials with longer follow-up to further clarify dose-response relationships.

ETHICAL DECLARATIONS

Informed Consent

Written informed consent from the patient is not required for the publication of this correspondence and related clinical details.

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Conflict of Interest

The authors declare no conflicts of interest.

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