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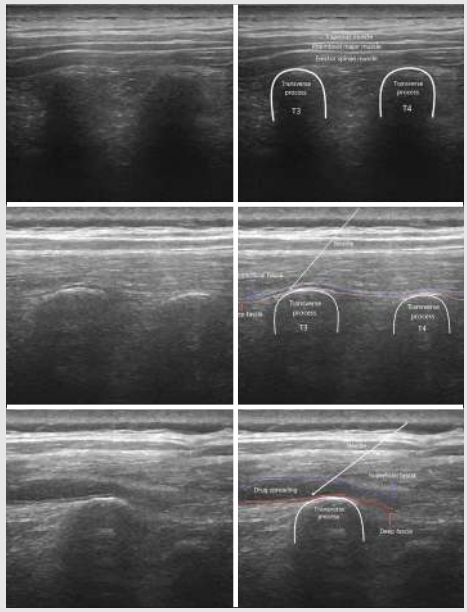

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REVIEW

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Myoma Uteri

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ABSTRACT

Uterine fibroids, also known as leiomyomas or myoma uteri, are benign smooth muscle tumors that arise primarily in women of reproductive age. These tumors are hormonally responsive, with their growth strongly influenced by estrogen and progesterone. Myomas can be asymptomatic or cause a wide range of clinical manifestations including menorrhagia, anemia, pelvic pressure, urinary disturbances, and infertility. The etiology involves genetic mutations, notably in the mediator complex subunit 12 and high mobility group AT-hook 2 genes, and environmental factors such as exposure to endocrine-disrupting chemicals. Epidemiological studies reveal higher prevalence in African descent and familial aggregation. Diagnosis is often achieved through pelvic examination and ultrasonography, whereas magnetic resonance ımaging remains the gold standard for complex cases. Fibroids are classified using the Federation of Gynecology and Obstetrics system based on their location relative to the endometrial and serosal surfaces. Medical management includes non-steroidal anti-inflammatory drugs, antifibrinolytics, and hormonal therapies, though they primarily target symptoms rather than tumor size. Surgical options such as hysterectomy, myomectomy, and minimally invasive techniques such as magnetic resonance-guided focused ultrasound are indicated for refractory cases. Future directions emphasize early diagnosis, individualized treatment, and the use of fibroids as a model to explore novel therapeutic strategies, particularly those aiming to interrupt fibroid pathogenesis at the molecular level. Given their accessibility and relatively benign nature, fibroids also provide a valuable platform for testing emerging technologies in gynecologic care. As research advances, the paradigm is shifting from radical surgical intervention toward personalized, fertility-preserving treatments.

Keywords: Estrogen, Federation of Gynecology and Obstetrics classification, Leiomyoma, Myoma uteri, Uterine myomas

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INTRODUCTION

Uterine myomas, also referred to as leiomyomas or fibroids, are benign tumors originating from smooth muscle cells and fibroblasts, characterized by an abundance of extracellular matrix. These growths typically arise during a woman's reproductive years, between menarche and menopause, with their development and gene expression influenced by cyclical fluctuations of gonadal steroids, particularly estrogen and progesterone. Fibroids represent a significant health concern for women of childbearing age, often leading to substantial morbidity. Common clinical manifestations include heavy or prolonged menstrual bleeding, which may result in iron deficiency anemia, as well as social discomfort. In addition, fibroids can cause uterine enlargement, leading to urinary issues such

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as frequency, nocturia, or retention, and gastrointestinal disturbances such as diarrhea or constipation. Abdominal bloating or pain may also occur, although some women remain asymptomatic even when fibroids reach considerable size.[1]

EPIDEMIOLOGY AND ETIOLOGY, INCIDENCE, AND PREVALENCE OF MYOMA UTERINE

Myoma uteri is a benign smooth muscle tumor and usually develops from the uterine corpus but can also occur in the cervix, uterine ligaments, and rarely in the ovaries and tubules. Its racial and familial characteristics indicate the importance of genetic risk factors in pathogenesis.[2] Although the etiology is not clear, the role of steroid hormones released from the ovary is important. While myoma uteri is not observed before puberty, it is observed during the reproductive years when the level of ovarian hormones increases. Unopposed estrogen increases the incidence of myoma uteri. At the same time, any factor that decreases endogenous estrogen levels and increases progesterone levels (such as pregnancy and oral contraceptive use) decreases the incidence of uterine fibroids.[3] The development and growth of fibroids are related to estrogen, progesterone, and their associated growth factors and proteins.[2]

Studies have found that fibroid tissue is significantly more sensitive to estrogen than normal myometrial cells from the same patient.[4,5] Semi-quantitative immunohistochemical studies with estrogen and progesterone show the effect of these two hormones on tumor development.[6] While myoma uteri may grow with estrogen use, most fibroids shrink after the use of gonadotropin-releasing hormone (GnRH) agonists.[7] Progestins, hormone replacement therapy, clomiphene citrate use, and pregnancy can cause rapid growth and sometimes hemorrhagic degeneration.[1] Studies based on X chromosome inactivation demonstrated by glucose-6-phosphate dehydrogenase isoform expression and other techniques show that myoma uterine is the proliferation of a single smooth muscle clone.[8]

Tumor-specific chromosomal abnormalities are detected in approximately 40–50% of fibroids. Among these abnormalities, t(12-14), (q15;q23-24), del(7) (q22q32), trisomy 12 and 3q deletion are the most common. According to many studies, estrogen hormone supports the relationship between the growth of myoma uterine and tumor formation.[9] Estrogen exerts its physiological effects on the target cell by binding to specific nuclear receptors. These receptors are ERα and ERβ.[10]

Compared to normal myometrium, the expression of many genes (such as connexin 43 gap junction protein, type I and type III collagen, insulin-like growth factor-1 [IGF-1], parathyroid hormone-like, peptide, and progesterone receptor genes) is increased in myoma uteri tissue. Aromatase P450, an estrogen synthetase involved in the synthesis of estrogen from androgen, is involved in fibroid growth. It is suggested that GnRH agonist treatment inhibits aromatase P450 enzyme and causes regression of fibroids.[11,12] Estrogen exerts a mitogenic effect on fibroid cells through phosphorylation of intracellular proteins (growth-related protein, phosphatidylinositol 3-kinase, phospholipase C, platelet-derived growth factor [PDGF], etc.) by protein kinase. Estrogen mediates the release of growth factors such as endothelial growth factor (EGF), IGF, and PDGF. Progesterone also plays an important role in the pathogenesis of myoma uteri.

Progesterone stimulates mitotic activity and proliferation in myoma.[13,14] The most common angiogenic factors in myoma uteri are vascular EGF and adrenomedullin. These factors are found in higher concentrations in myoma tissue than in normal myometrium. Heparin-binding growth factor (HBGF) is associated with fibroid formation and is mitogenic in fibroblasts and smooth muscle cells. HBGF is more potent than EGF and shows more affinity for EGF receptors.[15] Fibroid tissue contains an abundant extracellular matrix, which is why these tumors are also called fibroids. Although myoma uteri has a low mitotic index, it can grow rapidly. This suggests a mechanism other than mitosis for growth, namely alteration and remodeling of the extracellular matrix content.[16] The factors involved in the etiopathogenesis of myoma uteri are schematized in Figure 1.

Fibroids have been linked to events that occur during the fetal period in the formation of the uteri. The development of smooth muscle cells of mesoderm origin (up to 30 weeks of gestation) is slower than those of endoderm origin (up to 12 weeks of gestation). Therefore, these undifferentiated cells of mesodermal origin have a longer labile period during the fetal period. It has been suggested that fibroid progenitor cells are formed during this period as a result of the influence of some unknown factors and grow in the post-menarcheal period when both estrogen and progesterone are dominant.[17,18]

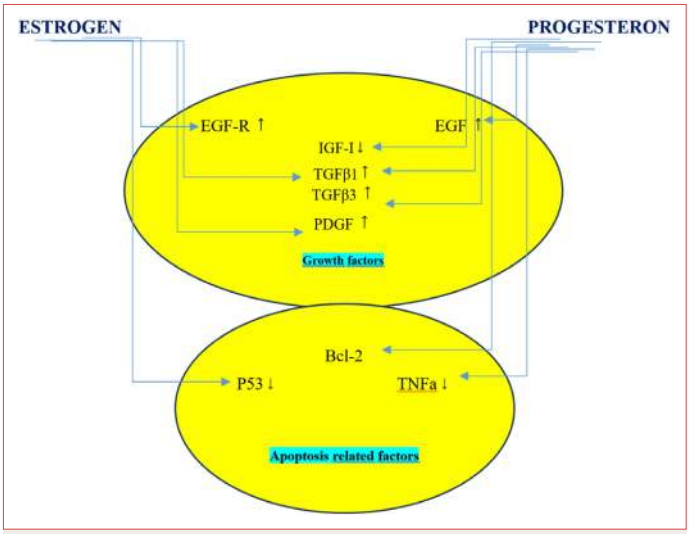


Figure 1. Schematic representation of the factors involved in the etiopathogenesis of myoma uteri.[17]

Myoma uteri is the most common benign tumor of the female pelvis and uterus and ranks first among all soft-tissue tumors. It has been detected in 50% of women in postmortem examinations.[9] It is seen in 20–30% of women of reproductive age. It is the most common indication for hysterectomy in the United States.[19] Myoma uteri is most commonly observed in women aged 50 years. Although it is very rare under the age of 30, cases occurring in adolescence have also been reported.[20] The actual incidence of myoma uterine is very difficult to determine. In pathologic examination of hysterectomy materials, the incidence of myoma uteri is as high as 77%.[21] In a Scandinavian study, asymptomatic women aged 25–40 years were evaluated by ultrasonography, and it was found that the prevalence of myoma uteri in these women was 5.4%, and the prevalence increased with age.[22] Clinical symptoms occur in 20–25% of women of reproductive age.[23] These tumors can be quite large in size and cause no symptoms or very small in size and cause symptoms. It is observed 3 times more frequently in the black race than in the white race. Myoma is frequently found in the family history of patients with myoma uteri.[24] It is 2.2 times more likely to be observed in 1st-° female relatives. Myoma in the pre-clinical stage can be detected in 24.7% of first-degree relatives. The incidence is approximately 12.8/1000.[25,26] Epidemiologic studies have shown a positive association between myoma uteri and a history of infertility and obesity and a negative association with parity, older age at delivery, and smoking.[27]

Myoma uteri are grouped according to their location in the uterus. In the uterus, fibroids are most commonly located in the corpus (91.2%), followed by the isthmus (7.2%) and cervix (2.6%).[28] Those located in the uterine corpus may be intramural (the most common location), subserous (under the visceral layer of the peritoneum), and submucous.

PATHOLOGY

Myoma uteri is usually a well-circumscribed, firm, round, gray-white tumor. It may appear raised and interlocked on the cross-sectional surface. It is a tumor made up of spindle cells. The cells fuse to form long intertwined ribbons. The structure of the cells is similar to normal myometrium tissue. Atypia and giant cells can be seen without increased mitosis. The cells around the tumor are concentrically flattened, appearing encapsulated (pseudocapsule), although not encapsulated due to the surrounding fibrous tissue. Blood supply comes from the periphery of the tumor, and the center of the tumor is relatively avascular, so necrosis and degeneration can be seen in the center of the tumor. Softening and yellow-brown discoloration can be seen in some areas, which are red regions of degeneration.[29]

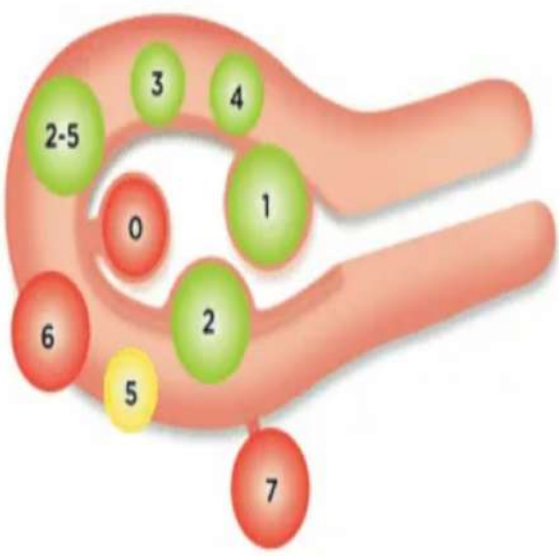
PATHOGENESIS

Fibroids, also known as leiomyomas, are thought to originate from a single mutated leiomyoma stem cell. This transformation is believed to occur following a genetic alteration, specifically, a point mutation affecting either the mediator complex subunit 12 gene or the high mobility group AT-hook 2 gene, the latter located on chromosome 12's long arm. Leiomyomas consist of three distinct cell types: fully differentiated cells, cells with intermediate differentiation, and fibroid stem cells. The rate of tumor growth is influenced by the proportion of these cell populations, with a higher concentration of stem cells associated with more rapid expansion. In addition, exposure to endocrine-disrupting chemicals potentially influenced by environmental conditions, race, or ethnicity may play a role in triggering these genetic mutations within myometrial stem cells.[30]

CLASSIFICATION OF MYOMA

Fibroids are heterogeneous in size and location. The International Federation of Gynecology and Obstetrics (FIGO) has developed a staging system that shows the location of fibroids according to mucosal and serosal surfaces. The International FIGO has developed a classification system for the causes of abnormal uterine bleeding in women of reproductive age based on imaging data. The system uses an 8-point numerical system to describe the location of fibroids relative to the endometrium (submucosal surface) and serosal surface, as given in Figure 2, with low numbers indicating a central location.[1,31]

- Type 0: Stalked fibroid localized in the submucosa and extending into the uterine cavity
- Type 1: More than 50% in the endometrial cavity, less intramural
- Type 2: <50% in the endometrial cavity, more intramural
- Type 3: Intramural fibroid adjacent to the endometrium. It does not show intracavitary extension
- Type 4: Myoma in the center of the myometrium, not associated with the endometrium or serosa
- Type 5: <50% subserous fibroids, more in the myometrium
- Type 6: More than 50% subserous fibroids and less intramural fibroids
- Type 7: Subserous fibroid with a stalk
- Type 8: Cervical fibroids and parasitic fibroids are included in this group.[1]



Category	Type	Description
Submucosal	Type 0	Completely intracavitary, pedunculated
	Type 1	Intramural portion less than 50%
	Type 2	Intramural portion more than 50%
Others	Type 3	In contact with endometrium, 100% intramural
	Type 4	Intramural
	Type 5	Subserosal, more than 50% intramural
	Type 6	Subserosal, less than 50% intramural
	Type 7	Pedunculated subserosal
	Type 8	Others (cervical, parasitic, etc.)

Figure 2. Federation of Gynecology and Obstetrics classification of myoma uteri.[1,31,32]

THE DIAGNOSIS

Diagnosing uterine fibroids presents several challenges due to the wide variability in their size, number, and anatomical location across patients. Moreover, the clinical presentation of fibroids is highly diverse, with symptoms that often overlap with other gynecological conditions such as ovulatory dysfunction, endometriosis, or endometrial polyps. Since many of the associated symptoms are common and non-specific, women may not immediately associate them with fibroids, leading to delayed diagnosis. In addition, asymptomatic fibroids can go unnoticed, allowing them to enlarge significantly over time, as illustrated in Figure 3.

Fibroid-related symptoms may involve gynecological, urinary, or gastrointestinal systems. The most frequently reported issue is heavy menstrual bleeding, though patients may also experience prolonged menstruation, pelvic discomfort or pressure, intermenstrual bleeding, and, in some cases, anemia due to excessive blood loss. Urinary complaints often include increased frequency and, less commonly, incontinence. In rare instances, fibroids may compress the ureter, potentially leading to hydronephrosis requiring intervention. Gastrointestinal manifestations, such as constipation or tenesmus (a persistent urge to defecate), can also occur. Furthermore, some individuals report back or leg pain linked to fibroid growth.

On physical examination, findings such as a firm, irregularly enlarged uterus or palpable masses originating from the uterus are suggestive of fibroids. Nevertheless, ultrasonography remains the primary diagnostic tool in clinical settings, allowing for the definitive identification of fibroids and differentiation from other pathologies, including ovarian malignancies.[1]

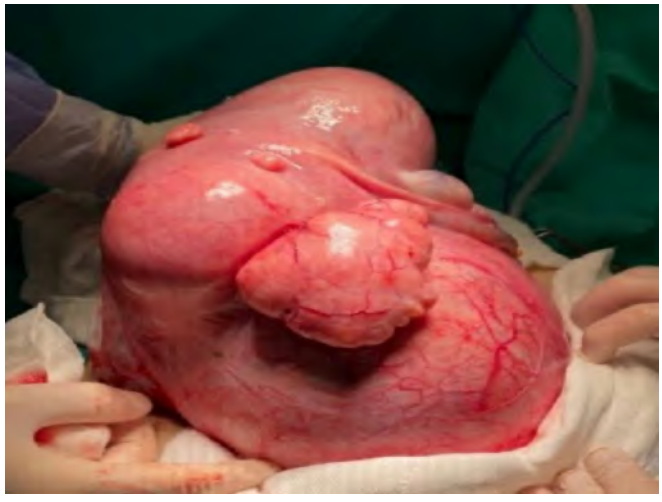


Figure 3. Intraoperative appearance of multiple fibroids reaching large sizes.

The detection rate of uterine fibroids varies depending on the diagnostic method used. While bimanual pelvic examination identifies fibroids in approximately 17% of women, this rate increases to 25.8% when transvaginal ultrasonography is employed. Several imaging techniques are available to enhance diagnostic accuracy. For instance, hysterosalpingography (an X-ray procedure assessing the uterus and fallopian tubes) can

assist in detecting fibroids; however, its diagnostic performance is limited by low sensitivity and specificity (50% and 20%, respectively) due to the absence of continuous real-time 3D imaging.

Magnetic resonance ımaging (MRI) offers a superior alternative, boasting near-perfect sensitivity and specificity rates approaching 100%. Despite its higher cost and more labor-intensive nature compared to ultrasonography, MRI is particularly valuable in select cases, such as patients with obesity, a history of pelvic surgery, or those unable to undergo transvaginal ultrasound or tolerate contrast agents. Moreover, MRI provides detailed anatomical and vascular information, which is crucial for pre-operative planning in complex surgical interventions or minimally invasive treatments such as uterine artery embolization and magnetic resonance-guided focused ultrasound (MRgFUS) therapy. Notably, the diagnostic yield of these imaging modalities improves with advancing age, paralleling the increased prevalence of uterine fibroids in older women.[1]

DIFFERENTIAL DIAGNOSIS

Although fibroids are easy to diagnose, thanks to the variety of pelvic examination and imaging modalities, they can be confused with some pathologies. The main differential diagnoses of fibroids are gynecologic: ovarian cysts, paraovarian-paratubal cysts, ectopic pregnancy, hematometra, hydrosalpinx, endometrial polyp, adenomyosis, adenomyoma, and malignancies (uterine sarcoma, endometrial cancer, and metastatic tumors).[1]

CLINICAL OUTCOME

At present, there is no standardized screening program for uterine fibroids, even among women identified as having a higher risk for developing these tumors. However, in cases where women present solely with infertility – without other typical fibroid-associated symptoms imaging techniques serve as effective tools to detect fibroids that could interfere with conception or pregnancy maintenance.[1]

MEDICAL TREATMENT

Various pharmacological options exist to manage symptoms related to uterine fibroids, including non-steroidal anti-inflammatory drugs (NSAIDs), antifibrinolytic agents, and hormonal therapies such as contraceptive steroids or the levonorgestrel-releasing intrauterine device (IUD). Despite their widespread use, systematic reviews highlight a lack of robust, high-quality evidence supporting the efficacy of many of these treatments. Nonetheless, this does not imply ineffectiveness or harm.

NSAIDs have demonstrated modest benefits in alleviating dysmenorrhea and reducing menorrhagia associated with fibroids, though they are generally less effective than hormonal therapies. Their affordability and over-the-counter availability make them a practical choice in many settings. Since excessive menstrual bleeding linked to fibroids is partly driven by local fibrinolytic activity, antifibrinolytics such as tranexamic acid are frequently recommended as first-line therapy. Tranexamic acid has been shown to significantly reduce menstrual blood loss, is well tolerated, and carries a favorable safety profile. However, neither NSAIDs nor antifibrinolytics impact fibroid volume.[1]

Hormonal contraceptives containing synthetic estrogen and progestins remain the cornerstone of medical management for fibroid-related heavy menstrual bleeding, reflecting the hormone-responsive nature of fibroids in women of reproductive age. Limited clinical trial data suggest that the levonorgestrel-releasing IUD effectively reduces bleeding in women whose fibroids do not distort the endometrial cavity. While levonorgestrel promotes endometrial thinning and offers long-acting reversible contraception, it does not significantly shrink fibroids. In addition, fibroid patients face a higher risk (12–16% over 3 years) of IUD expulsion, though predictive factors remain unclear. Concerns regarding potential long-term cardiovascular risks associated with systemic levonorgestrel require further investigation. Other progestin-only contraceptives, such as depot medroxyprogesterone acetate and implants, have shown promise in reducing fibroid risk, but their role in symptom management post-fibroid development remains underexplored. Notably, oral progestins at non-contraceptive doses have not proven effective for fibroid-related menorrhagia.[1]

SURGICAL TREATMENT

Surgical intervention is generally considered a secondary approach, reserved for women with FIGO type 3 or higher fibroids and persistent heavy menstrual bleeding unresponsive to medical therapy. Endometrial ablation, a minimally invasive procedure targeting the destruction of endometrial tissue, is suitable for women who have completed childbearing. It may be performed alone or in conjunction with hysteroscopic myomectomy, particularly in cases involving submucosal fibroids. However, since ablation is irreversible and does not offer contraceptive protection, it is often viewed as less favorable compared to the levonorgestrel IUD. Figures 4 and 5 illustrate a case of submucosal fibroid managed through hysteroscopic myomectomy followed by endometrial ablation.

For women seeking definitive treatment without future fertility desires, hysterectomy with ovarian conservation remains a highly effective option for managing fibroid-induced menorrhagia. Nonetheless, this approach carries greater procedural risks and morbidity compared to less invasive alternatives such as endometrial ablation.[1]

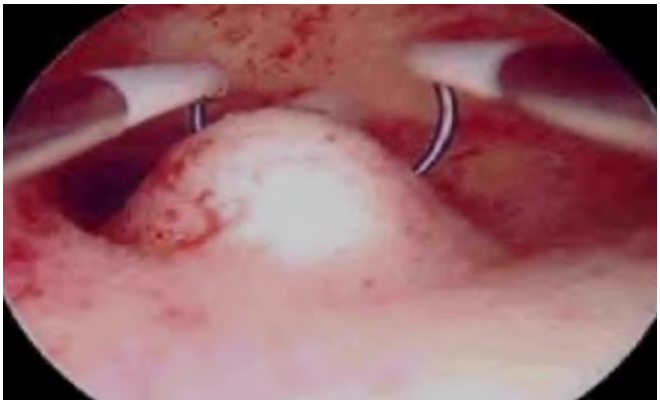


Figure 4. Hysteroscopic appearance of submucous myoma.

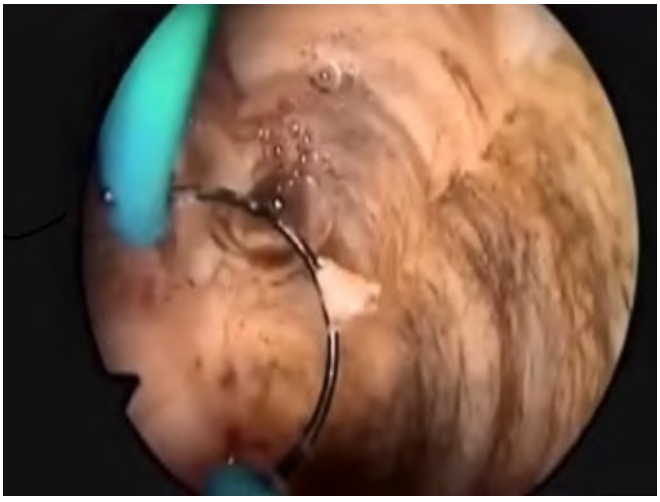


Figure 5. Hysteroscopic view of endometrial ablation.

For women experiencing fibroid-related heavy menstrual bleeding who are also seeking to enhance their fertility prospects, intramural fibroids may be surgically removed through laparoscopic, robotic, or traditional abdominal myomectomy approaches. Figure 6 illustrates a laparoscopic myomectomy procedure. Minimally invasive techniques, such as laparoscopy or robotic-assisted surgery, are generally favored due to reduced recovery times and lower complication rates, whereas open abdominal myomectomy is typically reserved for cases involving larger fibroids exceeding 10 cm in diameter. Before proceeding with surgical intervention, it is essential to conduct a comprehensive fertility assessment. This evaluation should include an analysis of ovulatory function, ovarian reserve, tubal patency, and semen parameters of the male partner to accurately identify underlying causes of infertility. Priority should be given to addressing other contributing factors

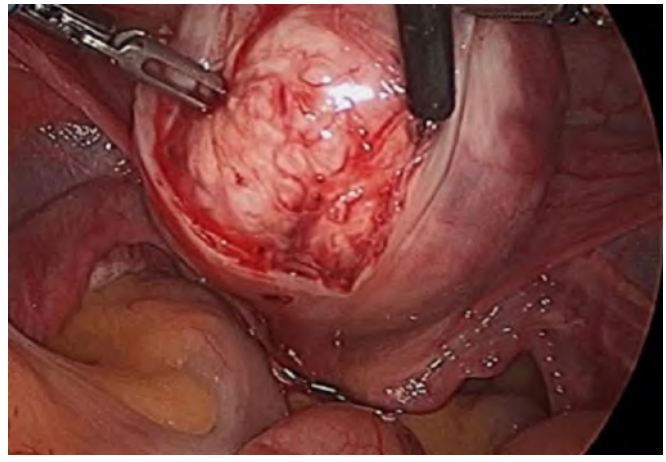


Figure 6. Intraoperative view of laparoscopic myomectomy.

to infertility prior to fibroid surgery, as operative management carries risks such as adhesion formation or inadvertent injury to pelvic structures that may further compromise reproductive potential.[1]

CONCLUSION AND RECOMMENDATIONS

The FIGO subclassification system remains the recommended framework for categorizing leiomyomas, providing a standardized approach essential for both clinical management and research. There is a critical need to expand and refine investigations into endometrial receptivity, particularly focusing on expression patterns within the tumor environment and adjacent endometrial tissue in cases involving type 1 through type 4 leiomyomas. Well-structured pre- and post-myomectomy studies are necessary to accurately classify fibroids based on type and other defining features, enabling meaningful comparisons of endometrial changes relative to baseline conditions. Furthermore, with the emergence of pharmacological agents designed for the long-term management of leiomyomas, it is imperative to assess their potential role in secondary prevention following surgical intervention, especially in younger patient populations.

The landscape of uterine fibroid treatment is poised for a significant evolution in the coming decade, driven by the urgent need to modernize outdated therapeutic paradigms. Similar to the shift from radical mastectomy to breast-conserving therapies in oncology, ongoing research is expected to facilitate a transition away from hysterectomy as the default treatment for fibroids. The future direction emphasizes the identification of prognostic markers and the development of personalized treatment strategies, promoting early intervention alongside both primary and secondary prevention measures.

Minimally invasive surgical techniques and medical therapies are anticipated to become the cornerstone of fibroid management. Innovations such as focused ultrasound therapy and the advancement of hysteroscopic or laparoscopic radiofrequency ablation offer targeted treatment of individual fibroids with reduced morbidity. In addition, the integration of image-guided interventions and molecularly targeted therapies promises to minimize the risks associated with conventional surgical approaches. Given that the transformation of myometrial stem cells into fibroid precursors appears to be a widespread biological process, future therapeutic strategies will likely focus on interrupting the progression phase of fibroid growth. As our understanding of the molecular and genetic mechanisms underlying fibroid pathogenesis deepens, novel therapies aimed at inhibiting tumor growth or inducing regression are expected to emerge.

Enhanced insights into fibroid biology may also improve the diagnostic differentiation between benign, pre-malignant, and malignant uterine conditions.

Finally, uterine fibroids present a valuable model for advancing treatment modalities applicable to oncology. Their prevalence, accessibility due to size, and the relatively low risk associated with incomplete treatment make fibroids an ideal platform for evaluating emerging therapies. This rationale underpinned their selection as the first indication for MRgFUS therapy. Consequently, fibroids can serve as an effective model system for assessing the true morbidity and efficacy of investigational treatments across a range of clinical applications.

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Long-Term Clinical Outcomes Following Anterior Cruciate Ligament Reconstruction Using Peroneus Longus Allograft: A 10-Year Case Series

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ABSTRACT

Objective: The aim of this study was to assess the long-term stability, functional outcomes, and patient satisfaction following anterior cruciate ligament (ACL) reconstruction using peroneus longus tendon allograft over a 10-year period.

Materials and Methods: This retrospective case series included 20 patients who underwent arthroscopic ACL reconstruction with a peroneus longus tendon allograft between August 2012 and September 2014. Clinical and functional outcomes were evaluated using Lysholm and Modified Cincinnati scores, Lachman and Pivot-Shift tests, KT-1000 arthrometer, and Cybex II isokinetic dynamometry. In addition, complication rates, graft failure, and long-term knee function were assessed.

Results: The mean follow-up duration was 10.3±1.5 years. The Lysholm score at the final follow-up was 98.65±3.32, with 95% of patients classified as having an excellent outcome. The Modified Cincinnati score was 29.45±1.14. Knee stability assessments showed that 60% of patients had a negative Lachman test, while 35% had a Grade 1 positive result and 5% had a Grade 2 positive result. The Pivot-Shift test was negative in 75% of patients, while 25% had a Grade 1 positive result. KT-1000 arthrometer measurements demonstrated slight differences in anterior tibial translation between the operated and contralateral knee. Muscle strength loss between the operated and non-operated limbs remained clinically insignificant. One patient (5%) experienced mild flexion restriction (<10° loss), and transient knee hypoesthesia was observed in 9 patients (45%) but resolved without intervention. No graft failure, re-rupture, immune response, or infections occurred during the 10-year follow-up.

Conclusion: Peroneus longus tendon allograft demonstrated excellent long-term clinical and functional outcomes with a low complication rate. It appears to be a viable alternative to autografts, especially for patients seeking to avoid donor site morbidity. Larger comparative studies are required to confirm these findings and assess long-term graft durability.

Keywords: Allografts, Anterior cruciate ligament, Anterior cruciate ligament ınjuries, Graft survival, Knee joint, Treatment outcome

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INTRODUCTION

Anterior cruciate ligament (ACL) reconstruction is one of the most commonly performed procedures in orthopedic surgery, and its long-term success is influenced by multiple factors. Among these, graft selection stands out as a critical determinant of surgical success. The biomechanical properties of the graft directly impact the healing process, post-operative complication risk, and long-term knee stability. Therefore, optimal graft selection is recognized as one of the key components of surgical success.[1-3]

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Hamstring tendon autografts are widely preferred due to their strong biomechanical properties, low donor site morbidity, and broad availability.[4] However, peroneus longus tendon allografts offer advantages including shorter surgical time, absence of donor site morbidity, and reduced post-operative pain.[5-8] Despite these benefits, concerns remain regarding the potential for immunological response and the long-term stability of allografts, with limited data available on their durability and clinical efficacy.[6,7,9,10]

This study aims to the long-term functional and clinical outcomes of ACL reconstruction using peroneus longus tendon allografts over a minimum 10-year follow-up period. We hypothesized that peroneus longus allografts would provide sustained knee stability, functional improvement, and high patient satisfaction over the long term.

MATERIALS AND METHODS

Study Design

This retrospective case series was approved by the institutional ethics committee (Approval no: 731 Date: December 27, 2016) and adhered to the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants in accordance with ethical guidelines.

Study Group

Patients included in the study underwent ACL reconstruction at our orthopedic clinic between August 2012 and September 2014 using a peroneus longus tendon allograft. Inclusion criteria were primary ACL rupture, a minimum 10-year follow-up, and availability of complete clinical and radiological data. Exclusion criteria included prior knee surgeries, multi-ligament injuries, and severe joint diseases.

Surgical Technique and Rehabilitation

All surgeries were performed by the same experienced surgeon using standard arthroscopic techniques. The sterilized peroneus longus tendon allograft was fixed within the femoral and tibial tunnels using interference screws to ensure stability. The post-operative rehabilitation protocol included initial restricted knee motion (0°–30°) with a brace for the first 2 weeks, gradual weight-bearing starting at 6 weeks, and return to full sports activities between 9 and 12 months post-operatively.

Outcome Measures

Primary study outcomes included clinical and functional assessments, stability tests, and muscle strength measurements.

- Clinical evaluation: Functional outcomes were assessed using the Lysholm and Modified Cincinnati scores
- Stability tests: Knee stability was evaluated with the Lachman test, Pivot-Shift test, and KT-1000 arthrometer measurements
- Muscle strength analysis: Quadriceps and hamstring strength were measured using Cybex II isokinetic dynamometry at 60°/s and 240°/s
- Complications: Adverse events such as graft failure, flexion limitation, and knee hypoesthesia were documented.

All measurements were performed during follow-up evaluations using standardized and validated methods.

Statistical Analysis

Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) Version 27 (SPSS Inc., IBM, NY, USA). Descriptive statistics (numbers, percentages, means, and ranges) were used to analyze pre-operative radiographic findings and post-operative functional outcomes.

RESULTS

Demographic Outcomes

This study included 20 patients, with 17 males (85%) and 3 females (15%). The mean age at surgery was 34.2±6.7 years (range: 21–46 years). The average time from trauma to surgery was 10.35±18.18 months (range: 1–84 months). The mean follow-up period was 10.3±1.5 years. Table 1 summarizes the demographic characteristics and trauma history of the patients.

Table 1. Demographic characteristics, trauma mechanisms, and clinical data of the patients

Characteristics	(n=20) (%)
Age	34.25±6.72
Gender (Female/Male)	(3/17)
Side (n)	
Left	5
Right	15
History of trauma (%)	
Football injury	50
Falling (after knee twisting)	20
Basketball injury	5
Skiing injury	5
Running injury	0
Kickboxing injury	5
Assault-related trauma	5
Motorcycle accident	10
Traffic accident	0
Time from trauma to surgery (months)	9.3±11.0
Follow-up duration (years)	9.8±0.4

Functional Outcomes

The mean Lysholm score was 98.65±3.32. Most patients (95%) had an "Excellent" outcome, while 5% were classified as "Good." The mean Modified Cincinnati score was 29.45±1.14, with all patients (100%) classified as "Excellent" (Table 2).

Based on the international knee documentation committee activity scale at the 10-year follow-up, 50% of patients resumed intensive activity (Level 1), 40% maintained moderate activity, and 10% were classified as having low activity. No patients were sedentary (Table 2 and Fig. 1).

Knee Stability Assessments

Knee stability was assessed using the Lachman test, Pivot-Shift test, and KT-1000 arthrometer to measure anterior tibial translation.

The Lachman test was negative in 60% of patients. A Grade 1 positive result was observed in 35%, while 5% had a Grade 2 positive outcome, indicating mild residual laxity in a small subset of cases.

The Pivot-Shift test was negative in 75% of patients, with 25% demonstrating a Grade 1 positive result (Table 3).

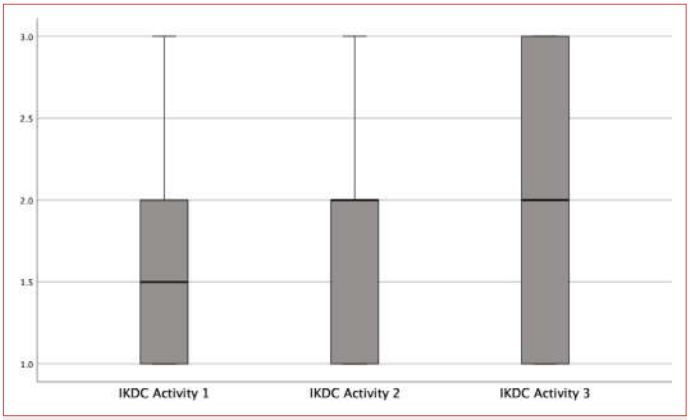

Figure 1. Distribution of international knee documentation committee activity levels (1, 2, and 3) of the study population.

KT-1000 arthrometer measurements, assessing anterior tibial translation under different force levels, are summarized in Table 4.

Isokinetic muscle strength was assessed at two different angular velocities, 60°/s and 240°/s, for both extension and flexion movements and the results are summarized in Table 5 and Figure 2.

Table 2. Functional outcomes, Lysholm and Modified Cincinnati Scores, and International Knee Documentation Committee Activity Levels of the study population

Variable	(n=20) (%)
Lysholm score	98.65±3.32
Good	1 (5)
Excellent	19 (95)
Modified cincinnati	29.45±1.14
Excellent	20 (100)
IKDC activity 1	
Intensive activity	10 (50)
Moderate activity	8 (40)
Low activity	2 (10)
Sedentary	0 (0)
IKDC activity 2	
Intensive activity	9 (45)
Moderate activity	8 (40)
Low activity	3 (15)
Sedentary	0 (0)
IKDC activity 3	
Intensive activity	7 (35)
Moderate activity	6 (30)
Low activity	7 (35)
Sedentary	0 (0)

IKDC: International Knee Documentation Committee.

Table 3. Knee stability test results in patients undergoing ACL reconstruction

Tests	(n=20)
Lachman test	
(–)	12 (60)
(+)	7 (35)
(++)	1 (5)
Pivot shift test	
Negative	15 (75)
Positive	5 (25)

ACL: Anterior cruciate ligament.

Table 4. KT-1000 arthrometer measurements in patients

KT-1000	(n=20)
15 pound	
Opere	7.21±2.48
Intact	6.67±2.6
20 pound	
Opere	9.21±2.93
Intact	8.53±3.02
30 pound	
Opere	11.16±3.12
Intact	10.32±3.21

Table 5. Isokinetic strength measurements using the Cybex II dynamometer in patients

Cybex II isokinetic dynamometer	(n=20)
Cybex opere extension 60°/s	158.45±39.31
Cybex opere flexion 60°/s	114.35±29.28
Cybex intact extension 60°/s	177.35±43.97
Cybex intact flexion 60°/s	118.10±29.23
Cybex opere extension 240°/s	74.55±20.24
Cybex opere flexion 240°/s	68.75±16.55
Cybex intact extension 240°/s	84.90±20.80
Cybex intact flexion 240°/s	71.60±17.40

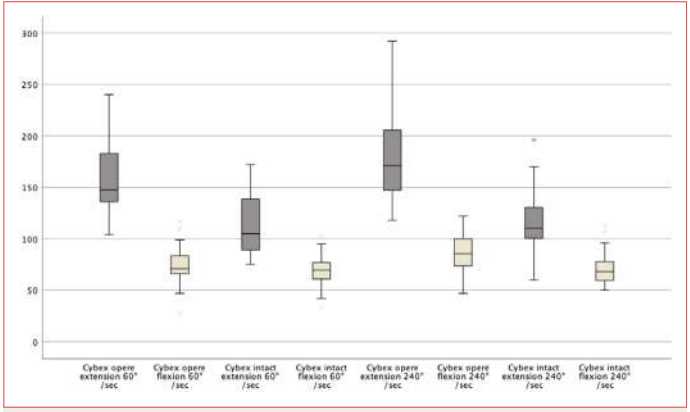

Figure 2. Isokinetic strength measurements using the Cybex II dynamometer in patients undergoing anterior cruciate ligament reconstruction.

Complications and Adverse Events

One patient (5%) experienced mild flexion restriction (<10° loss), but this did not significantly affect daily activities or overall functional outcomes. In addition, knee hypoesthesia was reported in 1 patient (5%), but it resolved over time without long-term neurological sequelae. No cases of graft failure, immune response, or infection were observed during the 10-year follow-up period.

DISCUSSION

The main finding of this study demonstrates that anterior cruciate ligament (ACL) reconstruction using peroneus longus tendon allograft provides favorable clinical and functional outcomes in the long-term follow-up. Based on the data obtained from our 10-year case series, we observed that the peroneus longus allograft maintains joint stability, supports functional improvement, and ensures patient satisfaction with minimal complications. Long-term results indicate that this graft choice is a reliable alternative for ACL reconstruction.

Our findings are consistent with the existing literature that highlights the advantages of peroneus longus allograft, particularly in terms of avoiding donor site morbidity and preserving muscle strength.[5-8] The absence of donor site morbidity may contribute to the high Lysholm scores observed in our study, aligning with previous reports that suggest allografts can enhance subjective outcomes by eliminating the negative effects associated with autograft harvesting.[11-14] Our findings showing stability over more than a decade are not inconsistent with these studies, but may not provide a clear judgment due to the limited sample size.

Stability assessments, including the Lachman test, Pivot-Shift test, and anterior tibial translation measurements with the KT-1000 arthrometer, revealed satisfactory results comparable to those reported in other long-term studies of allograft use.[15-17] Although some studies suggest that allografts may carry an increased risk of laxity over time,[18,19] our results did not indicate significant instability at the 10-year follow-up. This suggests that appropriate surgical techniques, graft preparation, and post-operative rehabilitation may mitigate the risks associated with allografts in ACL reconstruction.

Isokinetic muscle strength measurements demonstrated that the operated extremity retained strength comparable to the intact side, with muscle strength losses remaining within clinically acceptable limits. The long-term maintenance of muscle strength suggests that the peroneus longus allograft does not lead to significant deficits in lower extremity function, supporting its viability as a graft option.[20,21]

Complication rates were low in our case series. Minor issues such as flexion limitations and localized numbness were observed in some patients but did not significantly impact daily activities. While previous literature reports an increased risk of donor site morbidity with autografts,[8,22] the use of peroneus longus allograft eliminated this concern. In addition, although allografts have been associated with risks of infection and immune response,[23-25] no such complications were recorded in our cohort.

The main limitation of this study is the relatively small sample size, though all patients were selected as a homogeneous group and underwent surgery with a standardized technique. Another limitation is the lack of a control group; however, the primary objective was to evaluate the long-term outcomes of the peroneus longus allograft. Future comparative studies with larger cohorts and extended follow-up periods would further clarify the long-term durability and stability of this graft option.

CONCLUSION

Our study demonstrated that ACL reconstruction using peroneus longus tendon allograft provides favorable long-term clinical and functional outcomes. Considering its reliability, minimal donor site morbidity, and manageable risks of immunological response, this graft represents a viable alternative for ACL reconstruction. Our 10-year follow-up results support the sustained effectiveness of the peroneus longus allograft. However, further large-scale and comparative studies are necessary to validate these findings and assess long-term graft durability and stability in diverse patient populations.

DECLARATIONS

Ethics Committee Approval: The study was approved by Sisli Hamidiye Etfal Training and Research Hospital Ethics Committee (No: 731, Date: 27/12/2016).

Informed Consent: Informed consent was obtained from all individual participants included in the study.

Conflict of Interest: The authors declare that there is no conflict of interest.

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Authorship Contributions: Concept – RE, OTE; Design – RE, MK, OTE; Supervision – RE, YS, YY, MK, OTE; Data collection &/or processing – RE, YS, YY, OTE; Analysis and/or interpretation – RE, YS, MK; Literature search – RE, YS, YY, MK; Writing – RE, YS; Critical review – RE, YS, YY, MK, OTE

Peer-review: Externally peer-reviewed.

Footnote: This article is based on Rodi Ertoğrul's thesis entitled "Ön çapraz bağ lezyonlarının otojen hamstring tendon otogreft ve perenous longus allogreft ile rekonstrüksiyonu sonrası karşılaştırmalı erken dönem sonuçlarımız" completed in 2016 as part of the Medical Specialty Training Program.

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ORIGINAL ARTICLE

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Clinical Outcomes of Anterior Capsulodesis in Terrible Triad Elbow Injuries

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ABSTRACT

Objective: Terrible triad elbow ınjury (TTEI) is a complex trauma characterised by posterolateral dislocation, radial head fracture, and coronoid process fracture. Such injuries can lead to elbow instability and loss of function. The role of anterior capsulodesis surgery in the treatment of TTEI has not been fully established. The aim of this study was to evaluate the efficacy of anterior capsulodesis in patients with TTEI, to see its effect on elbow functional scores, to analyze possible post-operative complications, and to compare them with the literature.

Materials and Methods: This retrospective study analyzed 14 patients diagnosed with TTEI between 2017 and 2022. Patients with O'Driscoll type I-II and Regan–Morrey type I-II fractures were treated with a treatment protocol that included radial head fixation, lateral collateral ligament repair, and transosseous anterior capsulodesis. The mean follow-up was 23.2 months. Surgical outcomes were assessed using the Mayo Elbow Performance Score, Disabilities of the Arm, Shoulder, and Hand, and Broberg–Morrey classification.

Results: This study suggests that endobutton fixation of O'Driscoll and Regan–Morrey type I-II coronoid fractures in the treatment of TTEI has a positive effect on elbow function in the medium and long term. In particular, for fractures with limited coronoid involvement and capsular avulsion, anterior capsulodesis has been shown to improve functional outcomes and reduce the incidence of post-traumatic osteoarthritis.

Conclusion: Anterior capsulodesis is an effective option for the treatment of TTEI in terms of improving elbow function and reducing complications. When we reviewed the available studies in the literature, we concluded that anterior capsulodesis is a valuable procedure in the treatment of TTEI.

Keywords: Anterior capsulodesis, Elbow instability, Lateral collateral ligament repair, Mayo elbow performance score, Terrible triad elbow injury

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INTRODUCTION

The "Terrible Triple Elbow Injury" (TTEI) was first described by Hotchkiss. This injury involves posterolateral dislocation, fracture of the radial head, and fracture of the coronoid process. Stiffness is associated with unfavorable outcomes such as recurrent instability and reduced range of motion (ROM). It is therefore known as the "terrible triad."[1]

The main aim of treating these injuries is to restore the stabilizing bony structures of the elbow. Surgical treatment became popular after it was realized that non-operative treatment

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methods did not give very good results.[2] The principle of surgical treatment is based on two main objectives: Restoration of the bone stabilizers (radial head and coronoid process) and reconstruction of the soft-tissue stabilizers (radial collateral ligament).[3]

Miyazaki et al.[4] concluded that stable fixation of the coronoid process, restoration of the anatomy of the radial head by fixation of the fracture or radial head replacement, lateral stability by repair of the lateral ligament complex, and repair of the medial collateral ligament (MCL) if instability persists are the keys to preventing residual instability.

Despite advances in clinical knowledge and surgical techniques, there is still no standardized treatment protocol for TTEI. Although the pathoanatomy of this injury is now better understood, treatment algorithms remain controversial. To our knowledge, no study in the literature has specifically evaluated the efficacy of anterior capsulodesis in patients with terrible elbow triad (TTEI) presenting with O'Driscoll type I-II and Regan–Morrey type I-II coronoid fractures.[5,6] We hypothesized that anterior capsulodesis would have a beneficial effect on clinical and functional elbow outcomes. The aim of this study was to investigate the efficacy of anterior capsulodesis in patients with TTEI, and its effect on functional elbow outcomes, analyze the incidence of post-operative complications, and compare it with the literature.

MATERIALS AND METHODS

Study Design

This study was designed as a retrospective analysis of patients aged 18 years and older who presented to the emergency department of the Antalya Training and Research Hospital Orthopedics and Traumatology Department with a terrible triad of the elbow injury between 2017 and 2022. Patients were identified through a review of hospital records, including medical charts and imaging studies. The study protocol was approved by the Institutional Review Board of our hospital (Approval No: 19/27–December 05, 2024).

This study was conducted in accordance with the Declaration of Helsinki and relevant ethical standards. As the study is retrospective in design, informed consent from participants was not required. However, participant confidentiality was maintained, and all ethical guidelines were strictly followed.

Patients

A total of 14 patients met the inclusion criteria and were included in the study. Four patients were excluded due to the unavailability of clinical outcome data.

Inclusion Criteria

- Age ≥18 years
- Diagnosis of TTEI with an O'Driscoll type I-II or Regan–Morrey type I-II coronoid fracture
- Completion of outpatient follow-up.

Exclusion Criteria

- Patients who underwent radial head excision or prosthetic replacement
- Patients who underwent MCL repair
- Patients who did not undergo anterior capsulodesis.

All included patients underwent radial head fixation, lateral collateral ligament (LCL) repair, and transosseous anterior capsulodesis (Fig. 1). Demographic data, including age, sex, and mechanism of injury, were recorded for each patient.

Surgical Methods

The mean time from injury to surgery was 79 h. Written informed consent was obtained from all patients preoperatively. The operations were performed by the same surgical team using only a lateral incision. First, the fracture fragments of the radius head were removed, and then the anterior capsule and coronoid structure were evaluated. The attachment site of the anterior capsule was examined with the index finger, and the avulsed anterior capsule was fixed using transosseous tunnels and endobuttons with the elbow flexed 90°. Flexion and extension ROM were evaluated after fixation.

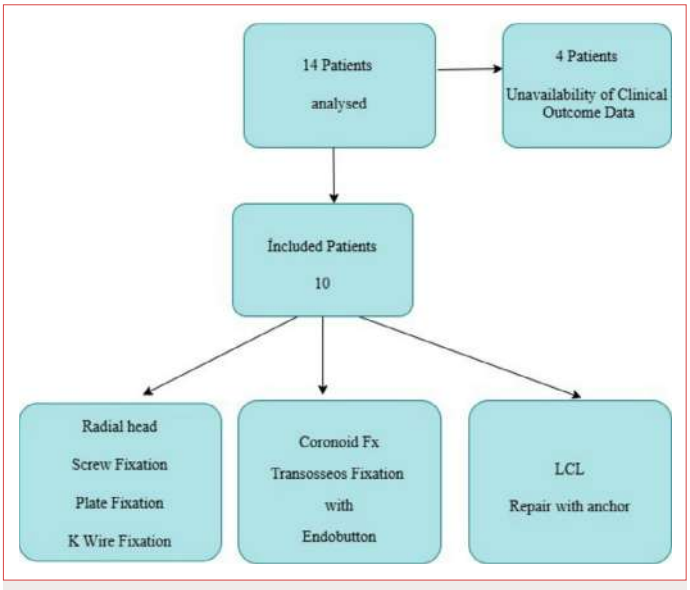

Figure 1. Included patients and surgical treatment flow chart.

Radial head fractures were fixed with headless screws, K-wires or plates (Fig. 2). Radial head excision or arthroplasty was not performed in any patient. According to the operative notes, eight patients had a complete tear of the LCL, and two patients had a 50% tear. In all cases, the LCL was repaired with transosseous sutures. Repair of the MCL was not required. Coronoid tip fractures were not fixed with plates or screws (Fig. 3).

Post-Operative Management

Post-operative follow-up was performed by the same surgical team. The arms of all patients were followed up in a long arm splint for 2 weeks postoperatively. Then, active ROM exercises were started after the splint was removed. Follow-up visits were weekly for the 1st month, monthly for the next 6 months, and then annually.

However, functional scoring and staging were performed by another independent orthopedist to rule out post-operative bias. Functional assessment was performed at the last follow-up visit using the Mayo Elbow Performance Score (MEPS).[7] The Disabilities of the Arm, Shoulder, and Hand (DASH) score was recorded at the last follow-up visit to assess post-operative functional capacity.[8] Radiological examinations were performed using the Broberg and Morrey classification system to assess arthritis changes.[9] Anteroposterior and lateral radiographs were also used to analyze fracture healing and joint alignment. Both DASH and MEPS scores were recorded by patients using online scoring platforms.[10]

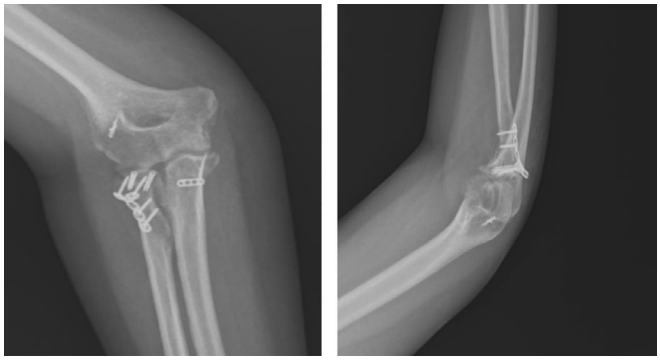

Figure 2. Radial head fixation with plate-screw, coronoid fixation with endobutton, LCL repair with anchor.

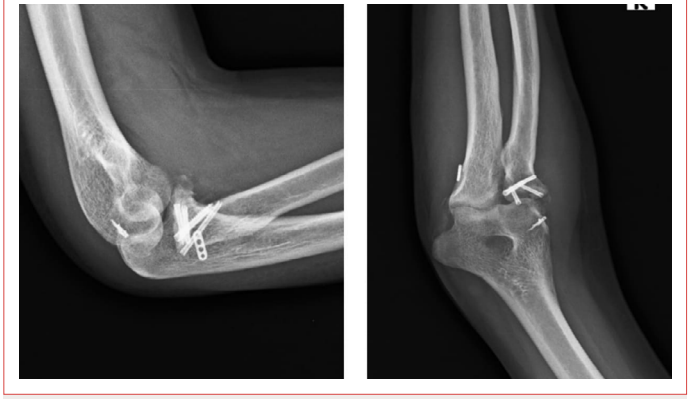

Figure 3. Radial head fixation with screw, coronoid fixation with endobutton, LCL repair with anchor.

Complications such as union problems, nerve damage, and infection were recorded during follow-up. Alignment of the humeroulnar and humeroradial joints and arthritic changes were evaluated.

Statistical Analysis

Demographic and clinical data of the patients were analyzed using descriptive statistics. Mean, standard deviation, minimum, and maximum values were calculated for continuous variables, whereas categorical variables were expressed as percentage distributions. The Shapiro–Wilk test was used to check the distribution of the elbow ROM and radiographic assessment data. Arthritis stages according to the Broberg and Morrey classification were reported as percentages. Mean MEPS and DASH scores were calculated. Complication rates were presented as percentages, and significance levels were tested by Chi-squared or Fisher's exact test. A value of $p<0.05$ was accepted as the statistical significance criterion in the analyses.

RESULTS

The mean follow-up period was 23.2 months (range: 18–32 months). The mean age of the patients was 43.8 years (range: 32–60). Of the 10 patients included in the study, three were female and seven were male. At the last follow-up, the mean flexion and extension ROM was 120° (range: 90°–140°) and the mean pronation and supination ROM was 140° (range: 60°–180°). No instability or discomfort was reported by any patient postoperatively (Table 1).

The mechanisms of injury were as follows: Two patients had a road traffic accident, six patients had a motorcycle accident, and the remaining two patients had a fall from a height.

Four patients had isolated elbow injuries, and six patients had additional injuries. Five patients had injuries on the dominant side and five on the non-dominant side. Pre-operative imaging consisted of bilateral elbow radiographs and computed tomography (CT) scans. Two patients developed pre-operative radial nerve injury, and one patient developed post-operative posterior interosseous nerve (PIS) injury. One patient had an open type 1 fracture.

Table 1. Patient characteristics and follow-up data

Mean follow-up period	23.2 months (range: 18–32 months)
Mean age of the patients	43.8 years (range: 32–60)
Ten patients were included in the study	3 (female), 7 (male)
Mean flexion and extension range of motion	120° (range: 90°–140°)
Mean pronation and supination range of motion	140° (range: 60°–180°).
Mayo Elbow Performance score	90 points (range: 80–100)
Disabilities of the Arm, Shoulder, and Hand	8–20
The mechanisms of injury	Two patients had a road traffic accident
	Six patients had a motorcycle accident
	Two patients had a fall from a height
Isolated elbow injuries	Four patients
Additional injuries	Six patients
Injuries on the dominant side	Five patients
Injuries on the non-dominant side	Five patients

During the evaluation process, elbow ROM, and humeroulnar and humeroradial joint distances were analyzed on antero-posterior and lateral radiographs. The Broberg and Morrey classification was used to assess the presence of arthritis. After at least 18 months of follow-up, no patient had stage 3 arthritis, three patients had stage 2 arthritis, and seven patients had stage 1 arthritis. The MEPS was calculated, and a mean score of 90 points (range: 80–100) was obtained for the entire cohort. Five patients achieved a MEPS score of 90 or higher, which is considered an excellent outcome.

Patients completed the 30-item DASH questionnaire, which assesses activities of daily living, upper extremity pain, and paresthesias. DASH scores ranged from 8 to 20.

No ulnar nerve pathology, elbow stiffness, radioulnar synostosis, joint dislocation, ulnar nerve impingement syndrome, instability, delayed union, subluxation, or heterotopic ossification complications were observed during post-operative follow-up. None of the patients required revision surgery. One patient developed post-operative PIN injury; this nerve showed signs of regeneration in the 1st month. Two patients had serous drainage at the wound site, which was successfully managed with serial dressings. Two patients had pre-operative radial nerve palsy, one of whom showed signs of nerve regeneration at 3 weeks postoperatively. Tendon transfer surgery was planned for the other patient with persistent nerve palsy.

DISCUSSION

In our study, the mean ROM for flexion and extension at the final follow-up was 120° (range: 90°–140°), whereas the mean ROM for pronation and supination was 140° (range: 60°–180°). No patients reported instability in either the early or late post-operative period. After a minimum follow-up of 18 months, no patients exhibited grade 3 arthritis, whereas three patients had grade 2 arthritis and seven patients had grade 1 arthritis. The MEPS was calculated, with a mean score of 90 (range: 80–100) across the entire cohort. Five patients achieved a MEPS score of 90 or higher, indicating excellent outcomes. The DASH questionnaire, which evaluates daily living activities, upper extremity pain, and paresthesia, revealed DASH scores ranging from 8 to 20.

Dislocations of the elbow are not common injuries and should be considered TTEI unless proven otherwise. After reduction, a CT scan should be performed to evaluate associated bone lesions.[11] In their study, Giannicola et al.[12] found that the ROM, MEPS, and DASH scores of the patients they analyzed were similar to our patients, but the post-operative complication rates, secondary osteoarthritis rates, and number of patients requiring revision were high. In a systematic review by Chen et al.,[13] both MEPS and DASH scores were found to be worse than the rates in our study. They also found the post-operative complication rate to be quite high. While heterotrophic ossification was not found in any of our patients, Chen et al.[13] found 12.5% heterotopic ossification in their study.

The management of coronoid tip fractures, which is an important component of TTEI injuries, is controversial.[14,15] The main aim of coronoid fixation is not to repair the ligament but to re-tension the anterior capsule. Tullos et al.[15] in 1981 mentioned the importance of the coronoid process in elbow stability. Subsequently, new classification systems related to

coronoid fractures were developed following the increase in studies in the literature related to the role of the coronoid in elbow stability. The study by Morrey and Regan is an important step at this point. They proposed a classification based on coronoid height and defined the categories of avulsion type (type I), <50% involvement (type II), and >50% involvement (type III). They also recommended fixation of type III coronoid fractures in their study.[5] O'Driscoll et al.[16] classified coronoid fractures according to size and anatomical location. In their study, they found that involvement of <2 mm usually did not require internal fixation. Another study on coronoid fractures was performed by Jeon et al.,[17] who reported that apical and mid-transverse fractures involving <50% of the coronoid height may not require fixation if the LCL and radial head are intact. In addition, it has been highlighted in the literature that the coronoid process is an important stabilizer for varus and internal rotation of the elbow.[18] We hypothesized that the clinical significance of coronoid fractures would depend not only on fracture size, displacement, or location, but also on damage to the anterior capsule, a critical structure for elbow stability. The results of this study support this hypothesis. We suggest that endobutton repair of the anterior capsule may improve stability, particularly in patients with capsular avulsion.

Recent studies have shown that MCL injury rates are high in patients with TTEI.[19] Although it has been suggested that MCL repair may prevent post-traumatic osteoarthritis (PTOA), long-term data on MCL repair after TTEI are still lacking.[20] Contrary to the literature, we did not perform MCL repair in any of our patients. We believe that PTOA is associated with anterior capsular stability. We conclude that anterior capsulodesis has a beneficial effect on long-term elbow function scores.

Surgical protocols for TTEI are not yet universally standardized. This study suggests that a single lateral incision is sufficient for TTEI and that the coronoid process should be fixed with the endobutton system regardless of its size or the site of fracture or rupture.

In our study, elbow stability in TTEI patients with coronoid fractures classified as O'Driscoll type I and II, Regan–Morrey type I and II was achieved with LCL repair, radial head fixation, and anterior capsulodesis. Anterior capsule fixation was performed with the endobutton system using transosseous tunnels. This approach resulted in improved DASH and Mayo Elbow scores compared to the literature. It also reduced the incidence of PTOA.

Limitations

This study has several limitations. First, its retrospective design poses challenges in establishing causality. In addition, the limited sample size, absence of a control group, and long-term follow-up constraints reduce the generalizability of the findings. Furthermore, uncertainties remain regarding the long-term effects of anterior capsulodesis. These limitations highlight the need for further research involving larger patient populations to provide more robust evidence.

CONCLUSION

This study demonstrates that endobutton fixation of O'Driscoll and Regan–Morrey type I-II coronoid fractures in the treatment of TTEI has a positive impact on elbow function in the mid-to-long term. The favorable outcomes of clinical functional assessment parameters following major injuries, such as TTEI, along with the successful results of osteoarthritis staging systems, are key findings that highlight the efficacy of anterior capsulodesis. This suggests that anterior capsulodesis may be a noteworthy treatment option in clinical practice. However, to optimize treatment protocols and comprehensively evaluate long-term outcomes in the management of TTEI, larger-scale, prospective, randomized controlled trials are warranted.

DECLARATIONS

Ethics Committee Approval: The study was approved by Antalya Training and Research Hospital Medical Research Scientific Ethics Committee (No: 19/27, Date: 05/12/2024).

Informed Consent: : Due to the retrospective nature of the study, the requirement for informed consent was waived by the institutional ethics committee.

Conflict of Interest: The authors declare that there is no conflict of interest.

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Peer-review: Externally peer-reviewed.

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ORIGINAL ARTICLE

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Emergency Medicine Physicians' Knowledge Level and Attitudes About Informed Consent in Invasive Procedures

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ABSTRACT

Objective: Informed consent is an ethical concept defined in law, which is applied in all health-care institutions. Informed consent is also one of the reasons for the medical intervention to be legally appropriate. The aim of this study is to evaluate the attitudes and experiences of emergency medicine physicians about informed consent in invasive procedures and their level of knowledge about informed consent in our country.

Materials and Methods: This study is a cross-sectional descriptive survey study and was conducted on emergency medicine residents and specialists actively working in emergency services. A total of 429 emergency medicine physicians participated in our study. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) 25.0 (SPSS, version 25) program for the data obtained in the study. $P<0.05$ was considered significant.

Results: A total of 244 (56.9%) emergency assistants and 185 (43.1%) emergency specialists participated in the study. 60.8% of the emergency medicine physicians participating in the study were male and 39.22% were female. The number of physicians who obtained informed consent for invasive procedures is not sufficient. The number of physicians who knew that informed consent should be obtained in invasive procedures was not sufficient. The general knowledge level of physicians about informed consent was not sufficient.

Conclusion: The rate of emergency medicine physicians who know the necessity of obtaining informed consent in invasive procedures is higher than the rate of physicians who obtained informed consent. Although some emergency medicine physicians know that informed consent is required for invasive procedures, they do not receive informed consent.

Keywords: Emergency medicine, Informed consent, Invasive procedure

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INTRODUCTION

Informed consent is an ethical concept defined in law, which is applied in all health-care institutions, and the basic criteria for informed consent are that the patient is capable of providing consent, has been sufficiently informed about the benefits and risks of the procedure to be performed and is not being forced to undergo medical intervention.[1] Legislation and practices regarding informed consent may show significant differences depending on the health system, legal structure, and cultural values of each country. Although written informed consent is not mandatory for minor surgical procedures in the laws of the Republic of Türkiye, it is recommended by health law professionals in respect of facilitating decision-making for the patient and providing proof for the physician in any potential case of medical malpractice.[2]

Informed consent is also one of the reasons for the medical intervention to be legally appropriate. An invasive intervention is illegal if made without obtaining informed consent. Other than emergency interventions such as cardiopulmonary resuscitation in the emergency department (ED), obtaining informed consent for invasive interventions is one of the pre-conditions for the medical procedure to be ethical and legal.[3]

Approximately 230 million invasive procedures per year are performed worldwide.[4] One of the most important obstacles in the process of obtaining appropriate informed consent is the limited time and number of patients in the ED.[5] When the indications and range of invasive procedures currently applied in EDs are taken into consideration, it is important to evaluate the level of knowledge about informed consent with the attitudes and experience of ED physicians.[6]

The aim of this study was to evaluate the level of knowledge about informed consent with the experience and attitudes toward informed consent for invasive procedures of emergency medicine physicians.

MATERIALS AND METHODS

Research Type and Planning

This study was designed as a prospective, cross-sectional, descriptive questionnaire-based study to measure the attitudes and level of knowledge of emergency medicine physicians about informed consent for invasive interventions. Approval for the study was granted by the Local Ethics Committee (decision no: 2022–275).

The study was conducted between October 15, 2022, and December 15, 2022. All the study participants were informed about the research, and consent of the physicians for voluntary participation in the study was obtained either through Google Forms or face-to-face. The study questionnaire was designed to be able to be completed in 5 min. The subjects included in the study were emergency medicine specialists or emergency medicine residents who were actively working in EDs in Türkiye and provided consent for participation in the research.

Sample Determination and Sample Content

In September 2022, a total of 4485 emergency medicine specialists and residents were working in Türkiye, and this was accepted as the study universe. The sample number representing this universe was calculated as 354 subjects with a 95% confidence interval ±5% error margin.

Questionnaire Items

The first section of the questionnaire included demographic data such as age, gender, time working in the profession, duration of working in ED, professional title, type of institution where working, number of patients presenting at ED in 1 day, number of interventional procedures performed in the ED where working in 1 day, and whether or not training had been received about health law. In the second section, it was questioned whether informed consent was obtained before performing invasive procedures. The third section of the questionnaire measured the level of knowledge about the need to obtain informed consent before the application of invasive procedures. The fourth section included questions about informed consent in various conditions that would be encountered by the physicians. A 5-point Likert-type scale was used when responding to the questions. The 5-point Likert scale used was defined as "1 (Completely disagree), 2 (Partially disagree), 3 (Neutral), 4 (Partially Agree), 5 (Completely agree)."The answers to the question "Is there anything you would like to add about informed consent in invasive procedures performed in the emergency department?" were evaluated and coded independently by three different people. Then, the main themes and sub-themes were determined with the consensus of these three people. The questionnaire was prepared based on previous literature and national and international laws such as human rights, biomedical agreements, and the management of patient rights. The reliability of the scale was tested with Cronbach's alpha coefficient, and the alpha value was found to be 0.88. This value shows that the scale is highly reliable.

Statistical Analysis

Data obtained in the study were analyzed statistically using IBM Statistical Package for the Social Sciences version 25.0 software (IBM Corp., Armonk, NY, USA). Descriptive statistics were stated as number (n) and percentage (%) for categorical variables and as median (Q1-Q3) values for continuous variables. The conformity of numerical variables to normal distribution was examined with the Kolmogorov-Smirnov test. To visualize the data, Tableau version 2022.2 software (Tableau Software, Seattle, WA, USA) was used.

RESULTS

For the study, a questionnaire was administered to 446 emergency physicians, and the responses of 429 (96.19%) physicians who completed the questionnaire completely were included in the evaluation. 17 (3.81%) physicians were not included in the data analysis because their responses were incomplete. The 429 participating physicians comprised 261 (60.8%) males and 168 (39.2%) females, of which 244 (56.9%) were ED residents and 185 (43.1%) were ED specialists. The place of work was reported to be a tertiary-level training and research hospital by 312 (72.7%) physicians, a university hospital by 48 (11.2%), and a second-level hospital by 69 (16.1%). Health law training had been received by 144 (33.6%) physicians at congresses or symposia, and 285 (66.4%) stated that they had not received any training on health law (Table 1).

Table 1. Demographic data of physicians participating in the study

	Count (n)	Percentage
Gender		
Male	261	60.8
Female	168	39.2
Title		
ED resident	244	56.9
ED specialist	185	43.1
Institution		
Tertiary-level	312	72.7
University	48	11.2
Second-level	69	16.1
Health law training		
Yes	144	33.6
No	285	66.4

Descriptive statistics are given as n (%). ED: Emergency department.

The median age of the study participants was 31 years (Q1-Q3: 28–35 years), the median duration in the profession was 6 years (Q1-Q3: 3–10 years), and the median duration of working as an ED physician was 5 years (Q1-Q3: 3–8 years). The number of patients presenting at ED per day was reported to be a median 1,000 (Q1-Q3: 650–1800), and the median number of procedures performed in ED was 300 (Q1-Q3: 100–750) (Table 2).

When the ED physicians were questioned about their attitude to obtaining informed consent before performing selected procedures, 235 (54.8%) physicians stated that they completely agreed with the recommendation to obtain consent before a lumbar punction. The response of complete agreement was given by 157 (36.6%) physicians for tube thoracostomy and by 143 (33.3%) for the placement of small diameter pleural drainage catheter and thoracentesis. For the invasive procedures that are performed more often in ED, such as nasogastric tube placement, 40 (9.3%) physicians responded that they completely agreed with the recommendation to obtain informed consent (Fig. 1).

The ED physicians were questioned about the need for informed consent in selected procedures. The response of complete agreement with the need for informed consent was given by 261 (60.8%) of the ED physicians for lumbar punction, 227 (52.9%) for thoracentesis, 219 (51%) for central venous catheter placement, and frequently performed procedures of nasogastric tube placement and intramuscular injection, by 147 (34.3%) and 179 (41.7%), respectively. The rate of physicians who knew that it was necessary to obtain informed consent was higher in all procedures than the rate of physicians who obtained informed consent (Fig. 2).

In the questions related to informed consent in ED, which were asked in the fourth section of the questionnaire, 216 (50.3%) of the study participants stated that the greatest obstacle to obtaining informed consent was the high number of patients and workload. To the statement that informed consent is a right of the physician and a responsibility of the patient, 150 (35%) participants replied that they were

Table 2. Descriptive statistics

	n	Median	Q1	Q3
Age	429	31	28	35
Duration in the profession	429	6	3	10
Duration of working as an ED physician	429	5	3	8
The number of patients presenting at ED in 1 day	429	1000	650	1800
The number of procedures performed in ED in 1 day	429	300	100	750

Descriptive statistics are given as n (%) or median (Q1-Q3). ED: Emergency department.

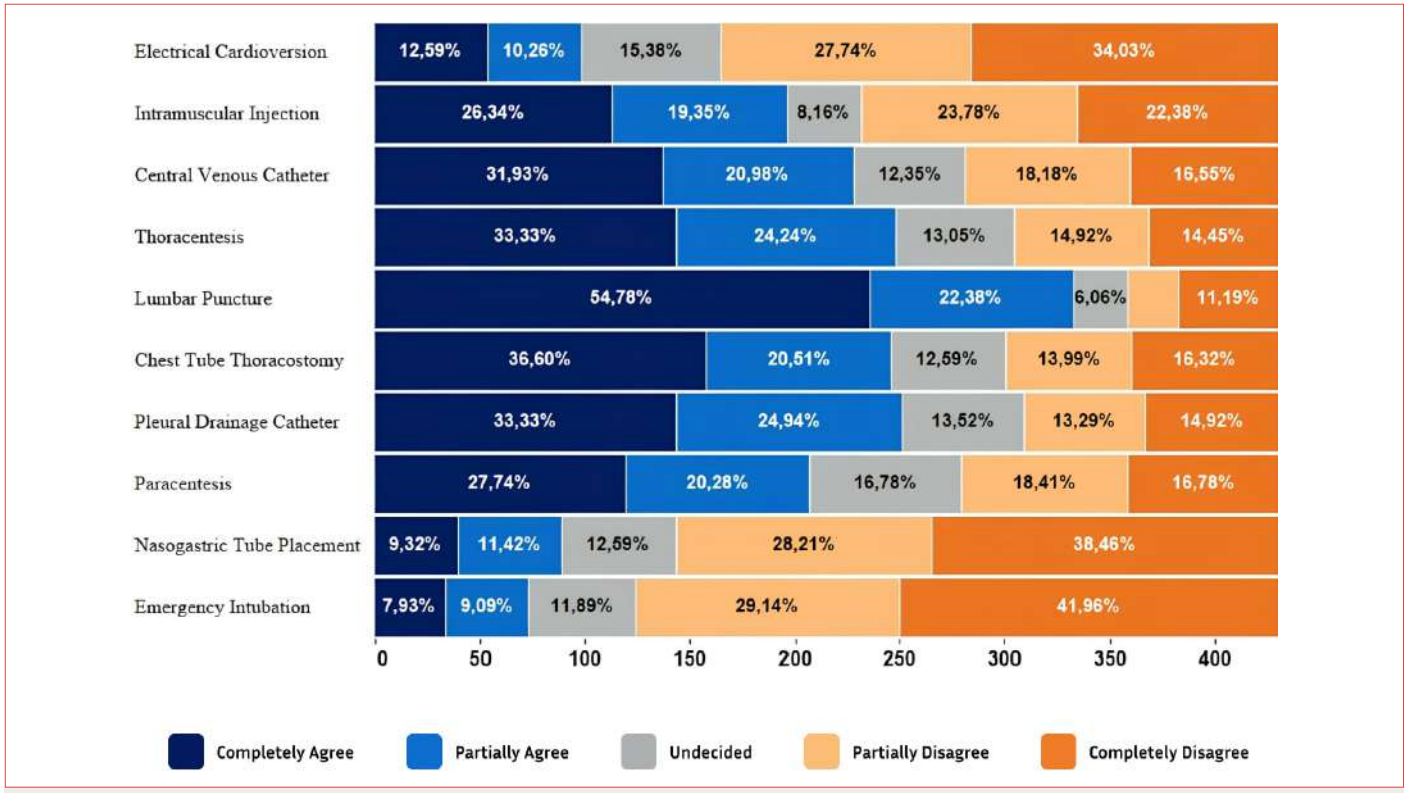

Figure 1. Physicians' attitudes about obtaining informed consent in the emergency department.

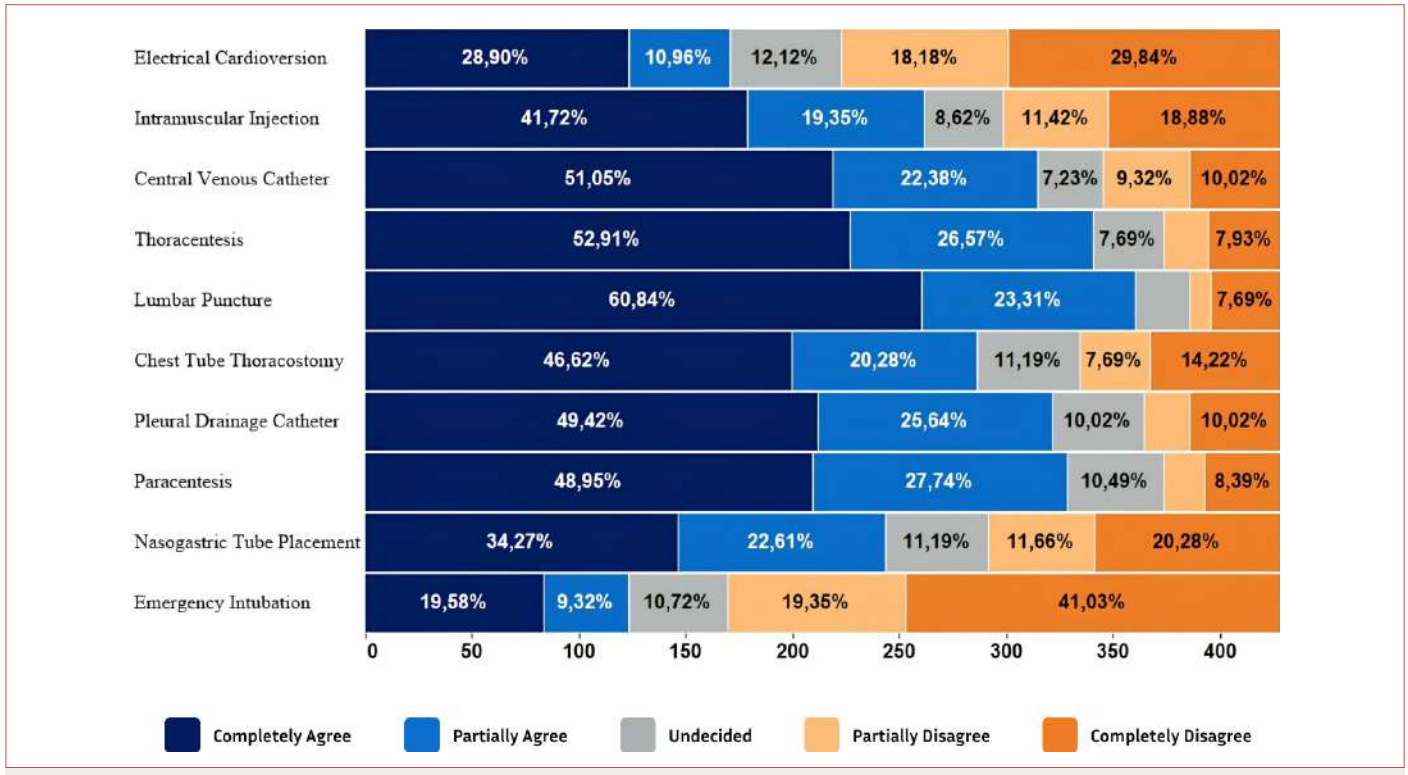

Figure 2. Physicians knowledge levels regarding the necessity of obtaining informed consent in the emergency department.

undecided. A total of 304 (70.9%) physicians completely agreed that medical intervention was not dependent on the patient's request in emergency conditions when consent could not be obtained from the patient, when the situation was life-threatening, or when the patient was unconscious (Fig. 3).

In the answers given to the question, "Is there anything you would like to add about informed consent in invasive procedures performed in the emergency department," the participants stated that it was difficult to implement informed consent in the ED. They do not have enough information about informed consent and they thought that consent was unnecessary (Table 3).

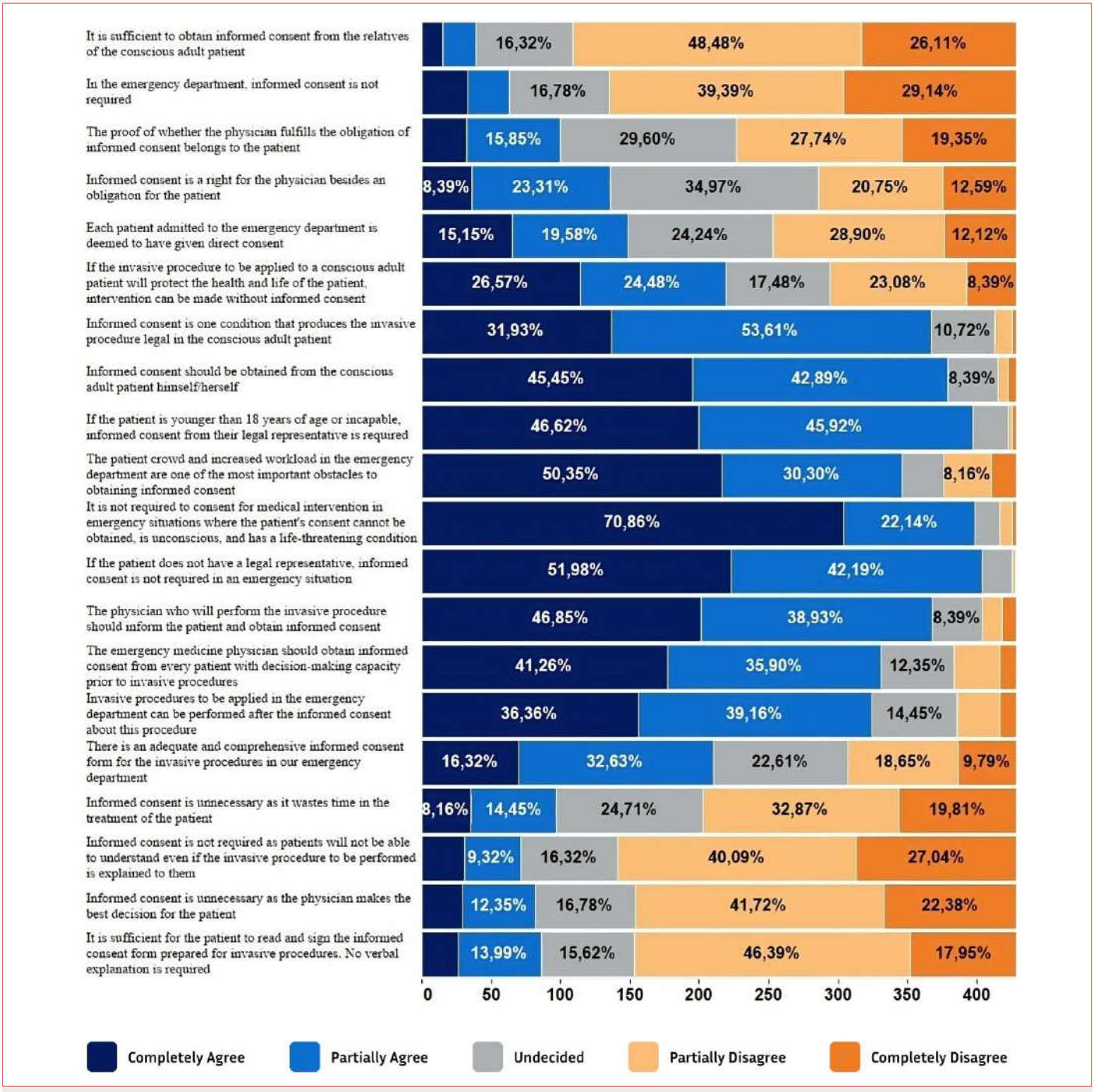

Figure 3. Physicians' knowledge levels regarding informed consent.

Table 3. The themes and examples of the responses to the question "Is there anything you would like to add about informed consent in invasive procedures performed in the emergency department?"

Main theme	Subtheme	Responder	Sample answer
The idea that it is unnecessary		A 32-year-old female emergency medicine assistant physician for 6 years. She works at a research and training hospital	I think it is an unnecessary practice
		A 34-year-male emergency medicine assistant physician for 9 years. He works at a research and training hospital	It is an unnecessary practice. If patients apply to the emergency department, they feel that they are emergency patients. In emergencies, patient consent is not required
		A 38-year-old female emergency medicine specialist physician for 8 years she works at a research and training hospital	It is an unnecessary workload. Because I do not think that some of the people who sign informed consent forms are aware of what they are signing
Implementation challenge	Patient-related barriers (Language barrier, Cognitive impairment)	A 30-year-male. Emergency medicine assistant. Physician for 5 years. He works at a research and training hospital	The patient needs to be informed, but because each patient has a different capacity to understand, we can never know whether the person fully understands the procedure and its necessity. I think that informed consent is not necessary, as not performing the procedure may also involve life-threatening risks for the patient
		A 28-year-old female. Emergency medicine assistant. Physician for 1 year. She works at a research and training hospital	There should be an easier method for illiterate people or a fingerprint signature should be enough. For those who do not speak Turkish, the hospital should be able to obtain informed consent in foreign languages
	Intensity	A 31-year-old male. Emergency medicine assistant. Physician for 5 years. He works at a research and training hospital.	Filling out informed consent forms increases the workload in emergency departments due to overcrowding
	Reasons arising from the organization and working environment	A 38-year-old male. Emergency medicine specialist. Physician for 12 years. He works in a secondary private hospital.	Informed consent is obtained because I work in a private hospital, but I did not obtain consent from many patients when I worked in a public hospital
Lack of education		A 32-year-old male. Emergency Medicine Assistant. Physician for 8 years. He works at a research and training hospital.	I feel inadequate in terms of knowledge about informed consent
		A 41-year-old female. Emergency medicine specialist. Physician for 13 years. She works at a university hospital.	Due to overcrowding in the emergency department or lack of education/knowledge of physicians, the habit of obtaining informed consent in emergency department physicians is less than it should be. Training programs should definitely include topics such as giving bad news and information to the patient and his/her relatives, and physicians should be trained on forensic duties and forensic cases
		A 44-year-old male. Emergency Medicine specialist. Physician for 20 years. He works at a university hospital.	I think there should be more frequent training on informed consent in emergency departments and detailed informed consent forms should be available.

DISCUSSION

The aim of this study was to evaluate the attitudes of emergency medicine physicians toward obtaining informed consent for invasive interventions and to question the levels of knowledge. Although obtaining informed consent for minor surgical procedures such as intramuscular injection is not mandatory in Turkish law, physicians should obtain written informed consent in respect of proof for a potential legal case.[7] In a study of physicians in a university hospital, Turla et al.[8] reported that a very low rate of physicians obtained consent for intramuscular injection or vaccination. In the current study, despite a higher rate of physicians who knew of the need for informed consent, the number of physicians obtaining consent was at a lower rate. The reason for this could be the high number of patients treated by physicians in ED and that they could not make the time for informed consent.

The results of the current study showed that the rate of physicians obtaining informed consent for lumbar punction was higher than the rate of physicians obtaining consent for other procedures. In a study by Patel et al.,[9] the number of physicians who obtained consent for lumbar punction in pediatric and adult patients was found to be similar to the rate in the current study. Gaeta et al.[10] reported that physicians knew of the need to obtain informed consent for lumbar punction, and the tendency to obtain consent was seen to be at a parallel rate. In the current study, the physicians reported the need to obtain informed consent for lumbar punction at a similar rate, but despite knowing the need to similarly obtain informed consent for other procedures, the tendency to obtain consent was seen to be at a lower rate.

In a study related to the use of written informed consent in the pediatric ED, Edwards et al.[11] found that written informed consent was obtained most often for procedural sedation, blood transfusion, and lumbar punction. None of the physicians in the pediatric ED obtained informed consent for the placement of the urinary catheter, nasogastric tube, or arterial blood gas sample taking. The current study results showed that while informed consent was obtained most often for lumbar punction, the rate for nasogastric tube placement was very low. Just as in other procedures, the rate of physicians obtaining informed consent for central catheter placement and tube thoracostomy was much lower than the rate of physicians who knew that informed consent should be obtained. Consistent with the literature, the findings of the current study showed that even when emergency medicine physicians knew of the need to obtain informed consent, the tendency to obtain consent was at a lower rate.[10] According to the current study results, the rate of physicians obtaining informed consent for central catheter placement and tube thoracostomy was at a higher level than that of physicians obtaining informed consent in pediatric EDs.[11]

Physicians do not have sufficient knowledge of the legal regulations related to informed consent and the outcomes of these, and the rates of applying informed consent in invasive procedures are low.[8] It has been previously reported that emergency medicine physicians would benefit from formal education about informed consent.[10] The current situation in Türkiye is that there are no lessons related to health law in the syllabus of medical faculties. Physicians obtain this information from training sessions at congresses and symposia and from experience in their professional life. Levels of knowledge about informed consent have been found to be low not only in emergency medicine but also in other branches.

In a study of surgical branch physicians, it was stated that importance should be given to education related to informed consent and that senior physicians should observe junior physicians.[12] Ashraf et al.[13] conducted a study with surgical branch physicians and concluded that young physicians did not have sufficient knowledge of informed consent. In another study of orthopedists, the conclusion was reached that even when there was consensus about the necessity for informed consent in ethical and legal respects, a significant proportion did not manage the consent process in daily practice, which was similar to the findings of the current study.[14] In a study by Wood et al.,[12] it was concluded that the experience of obtaining informed consent should be included in the medical faculty syllabus, and education should be given on this subject. Gong et al.[15] examined informed consent from the patient's perspective and concluded from that study that patients were never informed but that physicians made them sign the informed consent as required by the regulations and that, therefore, greater importance should be given to informed consent by making changes to the Chinese state medical faculty syllabus.

Not obtaining informed consent is an important factor in medical malpractice cases.[16] Krause et al.4 found that informed consent had an important place among the reasons for patients starting medical malpractice cases. According to Turkish law, when a medical intervention is performed without obtaining informed consent or with incomplete information given, the physician is legally responsible and may incur punishment as the medical intervention did not conform to the appropriate legal conditions.

Limitations

There were some limitations to the study, primarily that the physicians who were interviewed face-to-face stated that the questionnaire was long. The majority of the physicians in the study completed the questionnaire online. The subjective evaluations of the physicians may not have fully reflected the actual practices in daily life. In this study, it was not asked whether the participants had worked abroad or graduated

from a foreign medical school. This situation limits the possibility of evaluating the possible effects of differences in physicians' education and experience on the study results. A further limitation was that the majority of the physicians participating in the study worked in Istanbul, and this may have had a negative effect on the targeted sample.

CONCLUSION

The results of this study showed that although physicians were required to obtain informed consent for invasive procedures, many physicians did not obtain informed consent. The rate of emergency medicine physicians who knew that it was necessary to obtain informed consent was determined to be higher than the rate of physicians who obtained informed consent. It can be considered that although some emergency medicine physicians know that informed consent should be obtained when performing invasive procedures, they have the attitude of not obtaining informed consent because of the intense workload in the ED.

DECLARATIONS

Ethics Committee Approval: The study was approved by Istanbul Prof. Dr. Cemil Taşçıoğlu City Hospital Ethics Committee (No: 2022–275, Date: 03/10/2022).

Informed Consent: Informed consent was obtained from all individual participants included in the study.

Conflict of Interest: The authors declare that there is no conflict of interest.

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ORIGINAL ARTICLE

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Is the Interfascial Space a Potential Target for Neuromodulation in Pain Management?

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ABSTRACT

Objective: Interfascial space blockade is a common method for treating acute and chronic pain. This involves opening fascial adhesions and providing local anti-inflammatory and anaesthetic activity to relieve pain. Neuromodulation, which has rich nerve innervation, may enhance the effectiveness of this treatment. This study investigates the therapeutic effect of integrating neuromodulation with pulsed radiofrequency (pRF) into erector spinae plane (ESP) blockade.

Materials and Methods: This study was a single-blind, randomized controlled trial that included 56 patients with upper back pain caused by myofascial pain syndrome. One group received ESP block, while the other group received ESP block and pRF. Pain improvement was monitored using the visual analog scale (VAS) before and 30 min after treatment, as well as at 2, 4, and 12 weeks.

Results: Improvement was observed in both groups with treatment at all times (Friedman; Group Block $p=0.001$, Group Block+pRF $p<0.001$). The block and pRF group had lower VAS scores at weeks 4 and 12 compared to the block only group (Mann-Whitney U; week 4 $p=0.002$, week 12 $p<0.001$).

Conclusion: At the 12-week follow-up, both ESP block and pRF treatments added to ESP block were effective in relieving upper back myofascial pain. However, the addition of pRF significantly increased the effectiveness and duration of the treatment. The interfascial space presents a potential new target for pain management through neuromodulation.

Keywords: Erector spina plane block, Neuromodulation, Pain treatment, Pulsed radiofrequency, Upper back myofascial pain

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INTRODUCTION

Myofascial pain syndrome (MPS) is a frequent cause of chronic musculoskeletal pain due to the presence of myofascial trigger points. Although the incidence rate is on average 85%, it is more common in young- and middle-aged women.[1] The erector spinae plane (ESP) block is a used treatment for chronic pain caused by MPS.[2-5] It is a fascial block that has gained significant interest since its description in 2016 and is now used to treat both acute and chronic pain. The ESP block is carried out by accessing the fascia between the transverse process of the vertebra and the erector spinae muscle.

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Fascial blocks are considered to be effective by dissolving fascial adhesions by hydrodissection, anti-inflammatory effect by steroid injection, and modulation of peripheral and central sensitization by blocking free nerve endings with local anesthetic.[6,7] In the literature, the efficacy of ESP block in myofascial pain has typically been followed for an average of 6–8 weeks. The most emphasised mechanism of analgesic efficacy is drug diffusion. The drug spreads to the paravertebral area through the intertransverse connective tissue and to the epidural area through the intervertebral foramen. It then spreads to the erector spinae muscle and ultimately to the dorsal rami nerve endings within the muscle.[8]

The histological section of the trapezius muscle after the interfascial block revealed numerous nerve branches in the interfascial section. The text mentions the mechanism of myofascial pain relief through the effect of local anaesthetic on the nerve endings in this interval.[9] Currently, the mechanism of pain relief with fascial blocks is primarily attributed to the volume and content of the drug injected into the area. However, is this area open to neuromodulation due to its dense nerve network? Is pulsed radiofrequency (pRF), which is frequently used in chronic pain treatment, effective in this area? pRF works through a complex mechanism of action. It elicits electric field effects that result in changes in neural cellular substrates.[10]

Recent immunohistochemical studies suggest that the fascial network contains approximately 250 million nerve endings, making it the largest sensory organ after the skin.[11,12]

Furthermore, current research has highlighted the topic of cellular communication, which occurs faster than nerve conduction through quantum tunneling. The magnetic field generated by electrons in the cell membrane directly affects other cells, regardless of receptor stimulation. There is discussion of a communication speed that exceeds that of nerve conduction.[13]

It is possible that the pRF current, generated by an electric field, can create neuromodulation in the peripheral and central nervous system via a retrograde pathway from free nerve endings with cellular adaptation. However, there are few studies on this subject in the literature. Therefore, we investigated whether fascial neuromodulation is a viable treatment option for chronic pain. We investigated whether adding pRF treatment to the ESP block would extend the duration of pain relief in patients with upper back myofascial pain.

MATERIALS AND METHODS

This was a single-blind, randomized, controlled trial. Ethics committee approval was obtained from the ethics committee of Dışkapı Yıldırım Beyazıt Training and Research Hospital on July 04, 2022 (Decision no: 141/16). The study was conducted in accordance with the Declaration of Helsinki.

Randomization and Blinding

We used a computer-assisted randomization program to allocate patients into groups. We assigned patients sealed envelopes marked group 1 (block group)-group 2 (block+pRF group). The investigators who assessed the patients at the 3-month follow-up were blinded.

Participants

A total of 85 patients with upper back myofascial pain were evaluated and 60 individuals who met the inclusion criteria were included in the study from August 2022 to August 2023. Power analysis was performed using G*Power software to determine the required sample size for our study. Our initial data used for the power analysis included an effect size of 0.985, a significance level of $\alpha=0.05$, a desired power of $(1-\beta)=0.95$ and a total sample size of 56. These values were based on preliminary 12-week visual analog scale (VAS) mean and standard deviation (SD) data from 10 patients. The power analysis indicated that a sample size of 56 would be required to detect a significant effect with the specified parameters.

Inclusion Criterias

Individuals aged between 18 and 65 years, experiencing pain that is not restricted to a single dermatome or myotome, and exhibiting tight bands and one or more identifiable trigger points in the erector spinae muscles. Pain must be present when pressing the tender point on the erector spinae, assessed as ≥6 points on the VAS. Pain should be in the upper thoracic levels, tenderness should be detected by palpation, especially around the 3-4-5th thoracic vertebrae.

Exclusion Criterias

Patients undergo internal medicine, pulmonology, physiotherapy and rheumatology controls as a routine practice of our clinic and the following reasons were determined as exclusion criteria: upper back pain not due to malignancy, cervical or thoracic disc disease, not accompanied by rheumatological diseases that may cause chronic pain, not accompanied by severe depression or somatisation disorder, not associated with pregnancy or interventional procedure, not associated with bleeding diathesis or use of blood thinners.

The study design is depicted in Figure 1.

Treatment

ESP Block

All procedures were performed under sterile conditions and monitoring. All procedures were performed by the same physician with at least 5 years of experience in ultrasound (USG) and interventional procedures. The patient was placed in the prone position. The thoracic spinous processes and costae

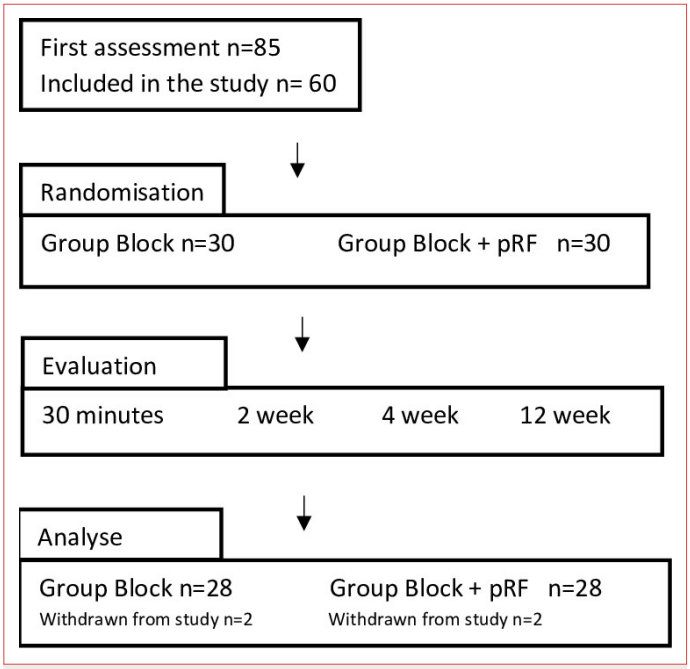

Figure 1. Flow chart diagram.

were scanned with a linear USG probe. Once the transverse processes were visualised, the spinal needle was inserted into the cephalic end of the transverse process using the inplane technique. Procedures were applied to the upper thoracic vertebrae (thoracic levels 3–5). Each patient was injected with 2 cc of dexamethasone, 8 cc of 0.5% bupivacaine, and 10 cc of saline in a volume of 20 cc. Patients were observed for 2 h for possible complications.

ESP Block + pRF

All procedures were performed under sterile conditions and monitoring. The patient was placed in the prone position. The spinous processes of the thoracic vertebrae and the costae were scanned with a linear USG probe. After visualisation of the transverse processes, a 10×10 cm cannula electrode was inserted into the cephalic end of the transverse process using the in-plane technique. 4 cc of saline was injected.

A radiofrequency generator (TOP Lesion Generator -10) and a 22-gauge 10 cm 5 mm active hybrid electrode (Equip, FIAB SPA, Italy) were used. A pRF current was applied for 8 min (5 Hz at 45 V, 5 ms at a temperature of 42°C). Each patient was then injected with 2 cc of dexamethasone, 8 cc of 0.5% bupivacaine and 6 cc of saline in a volume of 16 cc (A total of 20 cc was reached with 4 cc of saline injected before pRF). Patients were observed for 2 h for possible complications, (Fig. 2).

The white arrow symbolizes both the block needle and the radiofrequency cannula.

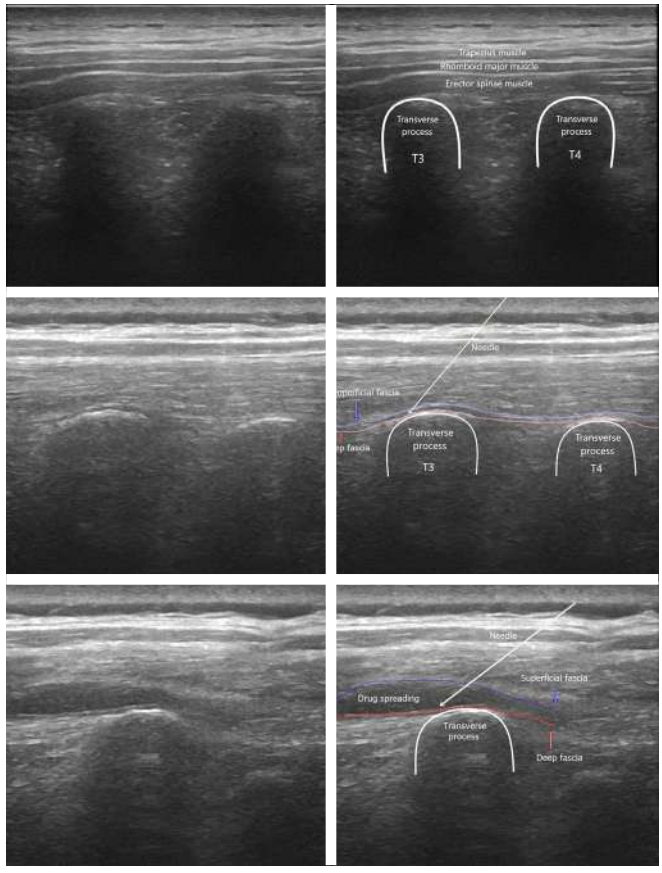

Figure 2. Intervention of erector spinae plane block and pulsed radiofrequency.

Outcome Assessment

We assessed all patients using the VAS scores before and 30 min, 2–4–12 weeks after treatment. Our primary objective was to ascertain the impact of treatment on pain intensity using VAS scores. Our secondary aim was to examine the side effects of treatment. For the VAS, a score of 0 indicated no pain and 10 represented the highest pain experienced during the most severe pain.

Statistical Methods

All analyses were conducted using Jamovi Project (2022, Jamovi Version 2.3, Computer Software). The findings of this study are expressed as frequencies and percentages. Normality analysis was performed using the Shapiro–Wilk test, skewness, kurtosis, and histograms. Normally distributed variables are presented as means and SD. Categorical variables were compared using the Chi-square test. Numerical dependent variables were compared between the groups using an independent sample t-test and Mann-Whitney U test. Repeated measures were analyzed using the Friedman and Wilcoxon test. Statistical significance was set at $p<0.05$.

RESULTS

There was no difference in age or gender between groups. There was no difference between pre-treatment, 30 min post-treatment, and week 2 VAS scores. The block + pRF group had statistically significantly lower VAS scores at weeks 4 and 12 compared to only block group (Mann-Whitney U test; p=0.002, p<0.001), (Table 1).

The groups were evaluated within themselves. In the Block group, a statistically significant decrease was observed at all time points after treatment compared to baseline VAS measurements (Wicoxon test; basal-30 min p<0.001, basal-2w p<0.001, basal-4w p<0.001, basal-12w p=0.005). In the block group, there was a statistically significant decrease in change over 12 weeks (Friedman test; p=0.001).

In the block + pRF group, a statistically significant decrease was observed at all times after treatment compared to the baseline VAS measurement (Wicoxon test; basal-30 min p<0.001, basal-2w p<0.001, basal-4w p<0.001, basal-12w p<0.001). The pRF + Block group showed a statistically significant decrease over 12 weeks (Friedman test; p<0.001), (Table 2 and Fig. 3).

No significant side effects that required treatment were observed during the procedure. Three patients experienced nausea and hypotension after the injection, but they recovered within half an hour and were kept under observation.

Table 1. Demographic characteristics and group comparisons

	Group Block		Group Block+pRF		test st.	p
	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)		
Age	50.93±11.81	52.5± (25–72)	36.36±10.17	40 (10–50)	0.774	0.442[a]
Gender						
Female (%)	23 (46)		27 (54)			0.084[b]
Male (%)	5 (83)		1 (17)			
VAS basal	8.75±1.14	9 (7–10)	8.46±1.81	9 (4–10)	390	0.973[c]
VAS 30 minutes	4±2.38	4.5 (1–9)	3.75±2.59	3.5± (1–10)	352.5	0.510[c]
VAS 2 week	3.32±2.38	2.5 (1–9)	3.14±1.6	3 (1–6)	395.5	0.953[c]
VAS 4 week	4.29±2.57	4 (1–9)	2.21±1.39	2 (1–6)	203.5	0.002[c]
VAS 12 week	6.86±2.69	7.5(1–10)	3.46±2.8	2 (1–10)	165	<0.001[c]

[a]: Independent samples t test; [b]: Chi-square test; [c]: Mann–Whitney U test; VAS: Visual analog scale; pRF: Pulsed radiofrequency. SD: Standard deviation.

Table 2. Change in VAS between all-time points and within 12 weeks

VAS	Basal	30 min	2 week	4 week	12 week	test st.	p*
Group block							
Mean±standard deviation	8.75±1.14	4±2.38	3.32±2.38	4.29±2.57	6.86±2.69	66.853	0.001
Mean rank	4.5	2.23	1.86	2.61	3.8		
p**		<0.001	<0.001	<0.001	0.005		
Group pRF+block							
Mean±standard deviation	8.46±1.81	3.75±2.59	3.14±1.6	2.21±1.39	3.46±2.8	60.98	<0.001
Mean rank	4.84	2.86	2.7	1.89	2.71		
p**		<0.001	<0.001	<0.001	<0.001		

p*: Friedman test; p**: Comparison with baseline VAS by Wilcoxon test; VAS: Visual analog scale; Min: Minutes; pRF: Pulsed radiofrequency.

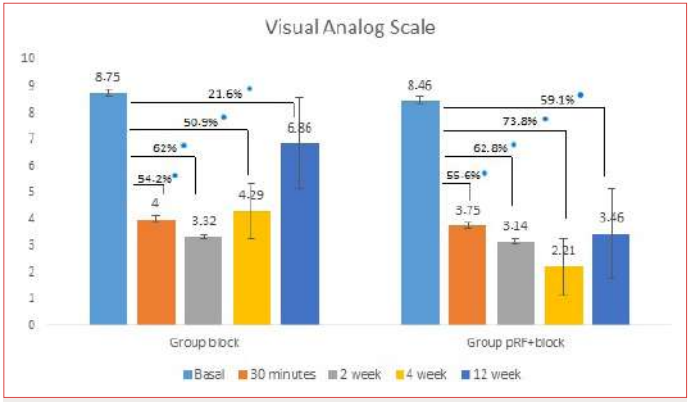

Figure 3. Temporal change of visual analog scale scale.

Blue spot: Between two time point P<0.05; pRF: pulsed radiofrequency.

DISCUSSION

The results of this study indicate a statistically significant improvement in both groups at the 12-week follow-up. Additionally, the group that received pRF in addition to ESP block had lower VAS scores at 4 and 12 weeks, with statistically significant differences compared to the only block group (p=0.002, p<0.001). Pain relief with fascial neuromodulation is more effective than blockade alone for up to 12 weeks. The pain improvement levels of the ESP block group were similar to the literature data; it will be discussed below in terms of interfascial pRF application in myofascial pain.[2-5]

The fascial continuum is recognized as adipose tissue with its innervation, specialised for each region where it is located. Adipose tissue serves as a source of energy, heat, and secreted biochemical substances. It also acts as a mechanical tension attenuator, interacting with metabolism through paracrine and autocrine modes. Fascial layers are structurally and functionally separated, as shown by macroscopic, three-dimensional microscopic examinations and immunohistochemical studies. Fascia has a dual phylogeny from mesoderm and ectoderm, as seen in embryological development.[14]

The fasciatome is a term used to identify the deep fascia layer supplied by the same nerve root and determine the main directions of movement. It is similar to the dermatome, which is a mapping method resulting from the rich innervation of the skin. Pain corresponding to the fasciatome is clinically recognized as radicular pain because it originates from the same nerve root.[15]

In MPS, the fascial system can be a source of pain due to its extensive nerve organization. This is not only because it is a tissue through which nerves pass but also because the connective tissue that forms the fascia is innervated and contains mechanoreceptors. Recent immunohistochemical studies on superficial and deep fascia have revealed this rich nerve network.

The superficial fascia has more autonomic and sensory nerve fibres, whereas the deep fascia has more proprioceptive and nociceptive fibres. Fede et al.[11] state that the superficial fascia is the most innervated tissue in the body after the skin. (skin>-Sup Fascia>Deep Fascia>Deep Adipose Tissue>Superficial Adipose Tissue). Larsson et al.[16] stated that superficial fascia acts as a mechanoreceptor, causing mechanical allodynia due to its dense autonomic fibres. These studies highlight the rich autonomic innervation of the superficial fascia. They suggest that stress, trauma, or sudden temperature changes can cause sympathetic activation not only in the skin but also in the superficial fascia. This mechanism also explains how external factors such as heat or manual therapy can improve fascial sensitivity and reduce pain.[17-19]

A review of immunohistochemical features of muscular/deep fascial innervation found that the thoracolumbar fascia is the most innervated fascia in both rats and humans. The study measured nerve fibre lengths and diameters of deep fascia containing proprioceptors and nociceptors, and the results showed an increase in both length and diameter of these fibres in pathological conditions. It has been reported that nociceptor density increases in inflamed fascia, also known as pathological fascia. Fascial nociceptors are part of the pain generator that can be predisposed by chemical and mechanical stimuli. From this perspective, chronic MPS may be hypothesized to result from fascial peripheral sensitization causing central sensitisation, which in turn causes chronic pain. Therefore, myofascial pain may be a problem of fascial origin rather than muscular origin.[12]

In another review examining the role of deep fascia in chronic pain, the main factor causing chronic pain in MPS is pathological fascia. As a result of immunohistochemical studies, an increase in both collagen and myofibroblast activity was observed in the tissue defined as pathological fascia. This increase is characterised by tissue stiffness and causes changes in the signalling of proprioceptive nerve endings located in the deep fascia. Another innervation change is the increased density and sensitivity of nociceptive nerve fibres. This has been associated with an increase in markers of inflammation, such as pro-inflammatory cytokines and immune cells. In summary, pain from deep fascia is probably due to a combination of increased nerve density, sensitivity, and chronic nociceptive stimulation, either physical or chemical.[20]

Can the rich neural network of deep and superficial fascia layers be a target tissue for neuromodulation with pRF? Can the fascial area be effectively used for pRF? pRF is a neuromodulation technique that generates an electric field to decrease pain

expression in the central nervous system through a series of reactions occurring in the neural substrates.[10,21,22]

The mechanism of action of pRF is not clear, although it acts through biological pathways. Modification mechanisms of pRF have been implicated in nociceptive signalling. This modification occurs through a variety of mechanisms, including neurotransmitters, ion channels, postsynaptic receptors, immune activity, microglial markers, inflammatory cytokines, and intracellular proteins.[21] pRF is effective in treating chronic pain in various anatomical locations and pain syndromes.[23-26] However, there is limited literature on pRF data in MPS. Bevacqua and Tamimi reported pain improvement in MPS patients with pRF applied to trigger points in case reports. Niraj found that 8 out of 12 patients experienced pain relief lasting 6 weeks after trigger point injection and pRF.[27-29]

Two studies compared pRF and block in the interfascial area. In the first study, conducted by Park in an MPS, one group received interfascial PRF to the gastrocnemius, and the other group received interfascial block. The pain scores of the PRF group remained lower for a longer period compared to the block-only group, with 50% pain relief in 2–4 weeks. It is worth noting that the pain scores measured immediately after the treatment were lower in the block group. The reason for this may be that the Prf group did not receive an injection of local anesthetic or steroid. The results indicate that interfascial blockade is more effective than pRF in the acute period.[30]

The other study conducted in the trapezius muscle in MPS involved two groups. One group received only interfascial block, while the other group received only pRF. Cho et al.[31] found that the recovery time was longer in the pRF group. Patients in both groups showed a significant decrease in Numeric Rating Scale (NRS) scores at 2, 4, and 8 weeks after treatments. Two weeks after each treatment, the decrements of NRS scores were not significantly different between the two groups. However, 4 and 8 weeks after the procedures, they found that the NRS score was significantly lower in the PRF group than in the block group.

We obtained similar results to the above studies, with a longer-lasting improvement in the pRF + block group compared to the block group. The decrease in VAS score between 30 min, 2–4–12 weeks before and after treatment was 54.2%, 62%, 50.9%, and 21.6% in the block group, respectively. pRF+block group showed 55.6%, 62.8%, 73.8%, and 59.1%, respectively. As can be seen, while both groups were similar at the first two measurements, pain scores continued to decrease in the pRF group at week 4. At week 12, there was still more than a 50% improvement.

In Park and Cho's studies, patients undergoing pRF were not injected with local anaesthetics or steroids in the interfascial space.[30,31] Park found that patients' pain scores were significantly higher in the pRF group than in the block group immediately after the study.[30] According to our results, the pain scores measured after 30 min were similar in both groups and statistically significantly lower than before treatment. In our opinion, the combination of local anesthetic and/or steroid injected into the interfascial area after pRF application provides patients with more comfort and less pain in the acute phase.

We gave each patient 4 cc of saline before the pRF application. Our aim was both to confirm that we were in the fascial area and to increase the electric field formation of pRF waves in a liquid medium. pRF achieves its main effect by creating an electric field.

Cellular transmission of the electromagnetic field through the cell membranes, known as quantum tunneling, takes place more easily in liquid media, and the synchronicity of this phenomenon is so great that as cellular functionality increases, the speed of information transfer is faster than the speed of nerve conduction. The expanding electromagnetic field spreads to other cells, keeping the whole body in communication.[13,32-34]

Based on all this information, we can form some ideas about how pRF produces a long-lasting activity. The rich fascial nerve network, especially the nociceptors located in the deep fascia, communicates with the central nervous system via A-delta and C fibres. These nociceptors contain large amounts of substance p and calcitonin gene-related peptides (CGRP).[35] Substance P and CGRP are important mediators in pain generation and trigger the onset of pain signalling. pRF modulates pain generation from the periphery to the central nervous system in a first step by etching these free nerve endings. This provides a longer-lasting improvement than interfascial blockade.

Study Limitations

The limitations of the study were that the follow-up period was limited to 12 weeks, and there was no third control group in which only pRF was applied. Another limitation was that we could not evaluate the effect of interventions on drug consumption, and there was no functionality scoring. The last restriction may be the uniqueness of the torasic levels used. For a more homogeneous application procedure, a treatment procedure applied at a single level could have been investigated.

CONCLUSION

Combined block with pRF applied to the ESP interfascial area has a longer-lasting effect than block alone. Local anesthesia and/or steroid injection after pRF application is beneficial for patient comfort and early pain improvement. There is a need for further studies and largeron neuromodulation of fascial areas in the treatment of chronic myofascial pain.

DECLARATIONS

Ethics Committee Approval: The study was approved by Dışkapı Yıldırım Beyazıt Training and Research Hospital Ethics Committee (No: 141/16, Date: 04/07/2022).

Informed Consent: Written informed consent was waived because of the retrospective nature of the study.

Conflict of Interest: The authors declare that there is no conflict of interest.

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ORIGINAL ARTICLE

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Can Long-Term Survival of Medial Opening-Wedge High Tibial Osteotomy Be Reliably Predicted?

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ABSTRACT

Objective: High tibial osteotomy (HTO) is an established joint-preserving procedure for medial compartment osteoarthritis with varus deformity. While it can delay the need for total knee arthroplasty (TKA), the long-term survival of HTO varies, and predictive factors remain under investigation.

Materials and Methods: This retrospective cohort study evaluated patients who underwent medial opening-wedge HTO between 2005 and 2017. Inclusion criteria were isolated medial osteoarthritis with varus alignment and a minimum 5-year follow-up. Patients were grouped based on whether they later required TKA. Pre-operative, post-operative, and final radiographic parameters – including mechanical tibiofemoral angle (mTFA) and medial proximal tibial angle – were measured by two blinded observers. Statistical analyses were performed to compare groups and identify potential predictors of failure.

Results: A total of 327 patients (295 females, 32 males) were reviewed; 34 (10.4%) underwent subsequent TKA at an average of 7.6 years post-HTO. Pre-operative mean mTFA was 12.48±4.25°, corrected post-operatively to −0.76±3.82° ($p<0.001$). Patients requiring TKA showed less optimal post-operative alignment and greater progression of lateral or patellofemoral joint degeneration. Higher pre-operative deformity and undercorrection after HTO were associated with increased risk of conversion to TKA.

Conclusion: Medial opening-wedge HTO can offer substantial joint preservation benefits, but a subset of patients progresses to TKA within a decade. Achieving appropriate mechanical alignment correction and careful patient selection are crucial for improving long-term survival. Understanding radiographic and demographic risk factors may help guide surgical planning and enhance native knee preservation in active populations.

Keywords: Ankle joint, Genu varum, High tibial osteotomy, Lateral distal tibial-ground surface angle, Total knee arthroplasty

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INTRODUCTION

High tibial osteotomy (HTO) is a well-established surgical technique aimed at treating unicompartmental medial knee osteoarthritis associated with varus deformity by realigning the mechanical axis to unload the degenerated medial compartment and transfer load toward the healthier lateral compartment.[1,2]

As life expectancy increases, the maintenance of functional mobility in the aging population becomes paramount, and preserving the native knee joint rather than proceeding directly to total knee arthroplasty (TKA) has gained importance, especially in younger and active patients.[3,4] Varus malalignment is a recognized mechanical risk factor for the progression of medial compartment osteoarthritis due to increased medial load transmission, cartilage wear, and eventual joint space narrowing.[5,6] In appropriately selected patients, HTO can provide substantial symptomatic relief, delay disease progression, and postpone the need for joint replacement.[2,4,7] However, despite advances in surgical techniques – such as the adoption of medial opening-wedge osteotomies supported by locking plates – long-term survival rates after HTO vary considerably, and some patients ultimately require conversion to TKA.[8,9]

Several factors have been associated with HTO outcomes, including patient age, body mass index, pre-operative severity of osteoarthritis, the magnitude of deformity correction, and post-operative rehabilitation protocols.[4,6,9] It has been demonstrated that optimal post-operative mechanical axis alignment, particularly achieving slight valgus positioning, correlates with better survival rates of the osteotomy and improved functional outcomes.[2,9] Conversely, undercorrection, overcorrection, residual varus, or disease progression in the lateral or patellofemoral compartments can result in clinical failure and necessitate TKA conversion.[5,7,10] In addition, surgical complications, such as non-union, infection, hardware irritation, and neurovascular injuries, although less frequent with modern techniques, remain concerns that can impact long-term success.[8,11]

As interest in joint-preserving strategies persists, it is crucial to further elucidate the predictors of failure and the longevity of HTO, especially with an increasing demand for high functional outcomes and longer prosthesis-free survival periods in active populations.[3,7,12] The present study aims to retrospectively evaluate the long-term results of medial opening-wedge HTO performed for medial compartment osteoarthritis with varus deformity, using conversion to TKA as the principal failure endpoint. By analyzing a homogenous cohort of patients, we seek to determine the survival rate of HTO and identify potential predictive factors associated with failure, including patient demographics, pre-operative deformity severity, achieved correction angles, and follow-up duration. A clearer understanding of these parameters may aid in refining patient selection criteria, optimizing surgical planning, and improving the long-term preservation of the native knee joint.[2,4,9] Furthermore, the study endeavors to contribute to the existing body of evidence by offering insights into the realistic expectations patients and surgeons can have regarding the durability and effectiveness of HTO in the context of contemporary orthopedic practice.

MATERIALS AND METHODS

Study Design and Ethical Approval

This study was designed as a retrospective, observational, and comparative cohort analysis. Institutional Review Board approval was obtained from the Ethics Committee of Baltalimani Bone Diseases Training and Research Hospital, University of Health Sciences (Approval No: 18/124, dated 28 February 2024). All procedures were conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent had been obtained from all patients at the time of their initial surgical treatment regarding the use of their anonymized medical data for research purposes.

Patient Selection

The institutional surgical database was retrospectively reviewed to identify patients who underwent medial opening-wedge HTO for medial unicompartmental knee osteoarthritis between January 2005 and December 2017. Inclusion criteria for the study were: diagnosis of isolated medial compartment knee osteoarthritis with varus malalignment; treatment with medial opening-wedge HTO; available complete pre-operative, post-operative (after HTO), and final post-operative (after subsequent TKA, if performed) radiographic imaging; and a minimum follow-up of 5 years after HTO.

Patients were divided into two groups:

- Group 1 consisted of individuals who underwent HTO and were later converted to TKA due to persistent symptoms or disease progression
- Group 2 included those who underwent HTO but did not require TKA during the follow-up period. Exclusion criteria were: incomplete medical records; inadequate radiographic follow-up; history of previous trauma, fracture, or surgery involving the ipsilateral lower extremity; inflammatory arthritis or neuromuscular disorders affecting gait.

Study Population

A total of 327 patients (295 females, 32 males) who underwent medial opening-wedge HTO were initially screened. Among these, 34 patients (33 females, 1 male) who subsequently required ipsilateral TKA were identified and included in the TKA

group. The mean age at the time of HTO was 57 years (range: 49–62 years), and the mean age at the time of TKA conversion was 64 years (range: 55–72 years). The time interval between HTO and TKA was on average 7.6 years (range: 5–11 years). In the TKA group, 20 patients (59%) had surgery on the left side and 14 (41%) on the right side. No specific age limitation was set for inclusion; however, all patients exhibited varus alignment of the lower extremity pre-operatively.

All HTO procedures were performed using the medial opening-wedge technique with fixation by locking plates. Subsequent total knee arthroplasties were performed with mechanical axis correction using standard instrumentation without navigation. Only patients with a minimum 5-year interval between HTO and TKA were included to ensure sufficient remodeling and adaptation periods for evaluating compensatory changes.

Radiographic Evaluation

Radiographic assessments included weight-bearing, full-length, standing anteroposterior (AP) orthoroentgenograms obtained at three timepoints: Pre-operative (before HTO), early post-operative (within the 1st year after HTO), and final post-operative (following TKA for those who underwent it). Radiographs were independently evaluated by two blinded orthopedic surgeons (H.B., S.G.), and the mean of the two measurements was used for statistical analysis to reduce interobserver variability.

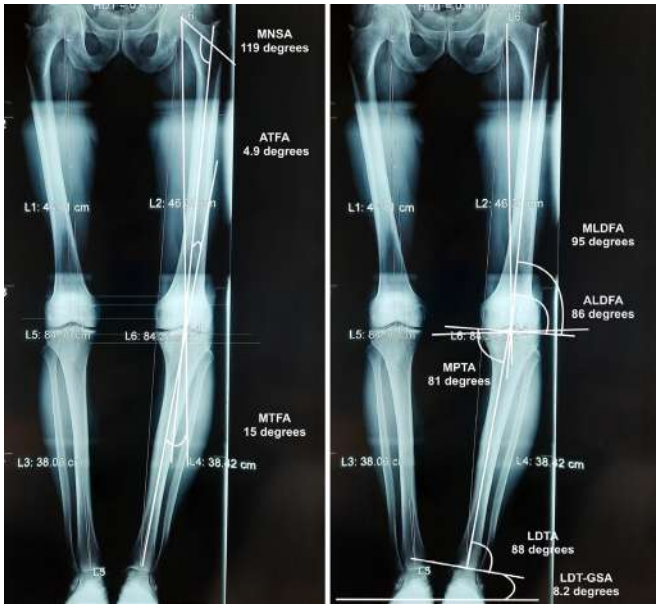

Figure 1. Angle measurements on standing orthoroentgenogram of the lower extremity taken before surgery.

The following parameters were measured (Figs 1-3):

- Mechanical tibiofemoral angle (mTFA)
- Anatomical tibiofemoral angle (aTFA)
- Mechanical lateral distal femoral angle (mLDFA)
- Anatomical lateral distal femoral angle (aLDFA)
- Medial proximal tibial angle (MPTA)
- Lateral distal tibial angle (LDTA)
- Lateral distal tibial-ground surface angle (LDT-GSA)

All measurements were performed using digital radiographic analysis software calibrated for limb-length images. On average, radiographic follow-up occurred at 4.6 years post-operatively (range: 3–5 years).

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as means and standard deviations. Categorical variables were presented as frequencies and percentages. The normality of data distribution was assessed using the Shapiro–Wilk test. For variables demonstrating normal distribution, paired samples Student's t-test was employed to compare pre-operative, post-operative, and

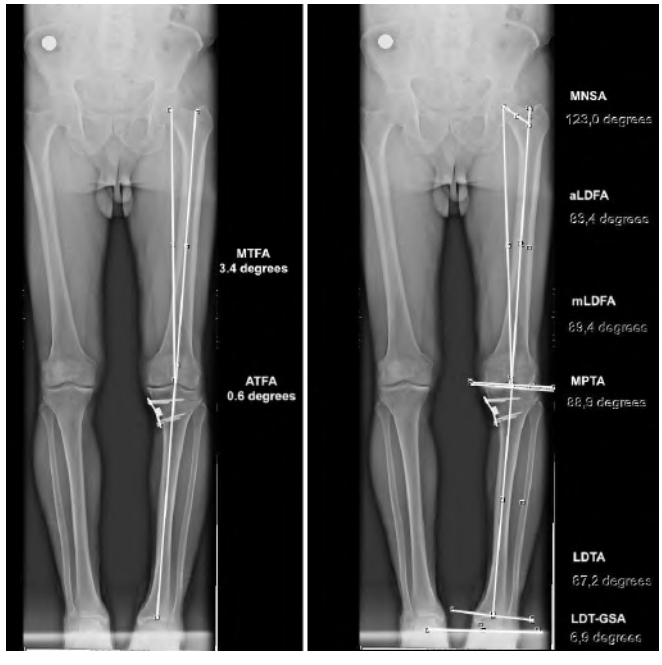

Figure 2. Angle measurements on standing orthoroentgenogram of the lower extremity taken after high tibial osteotomy.

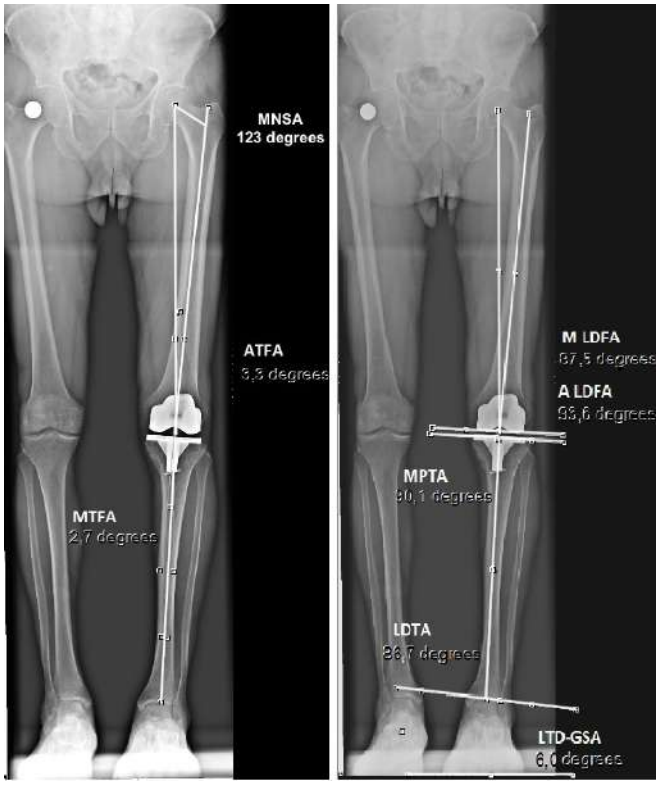

Figure 3. Angle measurements on standing orthoroentgenogram of the lower extremity taken after total knee arthroplasty.

final measurements. For non-normally distributed variables, the Wilcoxon signed-rank test was used. A two-tailed $p<0.05$ was considered statistically significant. Missing data points were handled by complete case analysis; no imputation methods were applied. Interobserver reliability for radiographic measurements was assessed by calculating the intraclass correlation coefficient (ICC), with an ICC value >0.80 considered indicative of excellent agreement.

RESULTS

Radiographic measurements were obtained from standing AP orthoroentgenograms at three distinct time points: Pre-operatively (before HTO), early post-operatively (after HTO), and at final follow-up (after TKA). The mean values, standard deviations, and statistical comparisons for each radiographic parameter are presented below.

mTFA

The mean pre-operative mTFA was 12.48±4.25°, indicating a varus alignment. Following medial opening-wedge HTO, the mean post-operative mTFA was corrected to −0.76±3.82°, demonstrating a statistically significant improvement ($p<0.001$). In patients who subsequently underwent TKA after HTO, the mean mTFA measured at the final post-operative evaluation was 7.35±14.91°. The difference between the post-HTO and post-TKA mTFA values was statistically significant ($p<0.001$).

aTFA

The mean pre-operative aTFA was measured at 5.83±4.50°. Post-operatively after HTO, the aTFA was corrected to −6.56±3.64°, and this change was statistically significant ($p<0.001$). After subsequent TKA, the mean aTFA was recorded as 3.66±3.04°. Comparison between the post-HTO and post-TKA aTFA values also revealed a significant difference ($p<0.001$).

MPTA

There was a significant increase in the MPTA following HTO compared to pre-operative values ($p<0.001$). In patients who later underwent TKA, the mean MPTA at final follow-up was 88.91±2.55°. The difference between post-HTO and post-TKA MPTA measurements remained statistically significant ($p<0.001$).

LDT-GSA

A statistically significant change was observed between the pre-operative and postoperative (post-HTO) LDT-GSA values ($p=0.002$). Following TKA, the mean LDT-GSA was measured as 4.63±2.46°. The difference between post-HTO and post-TKA LDT-GSA values was also statistically significant ($p=0.041$).

Other Radiographic Measurements

Although the main focus was on mTFA, aTFA, MPTA, and LDT-GSA, additional radiographic parameters, such as the mLDFA, aLDFA, and LDTA were also recorded. However, the differences in these parameters did not reach statistical significance across the evaluated time points. A comprehensive summary of all measurements, including statistically significant and non-significant data, is provided in Table 1.

DISCUSSION

In this study, we aimed to investigate whether correction of knee deformity via HTO and subsequent TKA would influence associated ankle alignment. Our principal finding was that although TKA following HTO significantly reduced varus alignment in the ankle, a residual varus deformity still persisted.

Knee deformities, particularly varus malalignment, are known to influence adjacent joints such as the ankle through compensatory mechanisms; however, this relationship has rarely been the primary focus of research.[6] Corrective procedures such as HTO address tibial metaphyseal deformities, but due to the nature of closed-chain biomechanics, abnormal force distribution across the ankle joint can lead to additional deformities.[7-9]

Table 1. Angular values and statistical analyses of patients with varus gonarthrosis before surgery, after high tibial osteotomy, and after total knee arthroplasty

	Pre-operative	Post-HTO	Post-TKA	Pre-operative versus Post-operative HTO p*	Post-HTO versus post-TKA p*
mTFA					
Mean	12.48	-0.76	7.35	<0.001	<0.001
SD	4.25	3.82	14.91		
aTFA					
Mean	5.83	-6.56	3.66	<0.001	<0.001
SD	4.50	3.64	3.04		
aLDFA					
Mean	85.21	85.21	85.26	n.s	0.764
SD	3.64	3.64	2.78		
mLDFA					
Mean	91.59	91.59	91.88	n.s	0.622
SD	3.32	3.32	2.99		
MPTA					
Mean	84.29	96.65	88.91	<0.001	<0.001
SD	2.90	3.01	2.55		
LDTA					
Mean	88.03	88.32	88.26	0.599	0.985
SD	3.86	2.92	3.29		
LDT-GSA					
Mean	7.63	5.21	4.63	<0.002	0.041
SD	4.98	2.28	2.46		

HTO: High tibial osteotomy; TKA: Total Knee Arthroplasty; mTFA: Mechanical Tibiofemoral Angle; aLDFA: Anatomical Lateral Distal Femoral Angle; mLDFA: Mechanical Lateral Distal Femoral Angle; MPTA: Medial Proximal Tibial Angle; LDTA: Lateral Distal Tibial Angle; LDT-GSA: Lateral Distal Tibial-Ground Surface Angle; SD: Standard deviation.

In our study, lower pre-operative LDT-GSA values were associated with greater knee varus, supporting the notion that patients with varus knees utilize compensatory mechanisms at the ankle joint.[10] Previous literature has reported compensatory valgus orientation of the ankle joint in varus knees.[11] In our cohort, the mean pre-operative LDT-GSA was in valgus; after HTO, it shifted significantly toward varus but remained in residual valgus.[6]

Our findings align with Kazemi et al.,[12] who demonstrated a significant correction in the LDT-GSA following HTO, despite no significant changes in distal tibial parameters such as the LTDA. Similarly, in our series, while foot pronation decreased, the residual ankle valgus persisted, reflecting incomplete reversal of compensatory changes. Following TKA, knee deformities were neutralized, and compensatory ankle malalignment also tended to improve, although not fully corrected.

Our results are consistent with Gao et al.,[1] who reported that ankle alignment improves after TKA when knee deformity is corrected. However, despite mechanical alignment being restored via TKA in our patients, the ankle joint did not completely revert to normal, suggesting partial but not total biomechanical recovery. The observed regression in MPTA after TKA, despite remaining within a functional range, highlights the interconnected biomechanical relationship between the knee and ankle.

We used mechanical alignment rather than kinematic alignment, which may partly explain the persistence of minor varus stresses post-operatively.[13] Importantly, although HTO successfully valgized the knee and TKA neutralized it, the sequence of interventions may influence the degree of residual deformities across both joints. Recent studies have increasingly highlighted outcomes that align with the findings of the present work.[12,14] Specifically, Karasavvidis et al.[13] reported high long-term success rates in similar patient populations, underscoring the durability of the intervention. Furthermore, both Jeong[14] and Matsumoto et al.[15] demonstrated that clinical improvements are consistently correlated with favorable radiographic and functional outcomes. In addition, in their work, Graef et al.[16] emphasized the critical role of minimizing complication rates in achieving sustained implant longevity. Consistent with these reports, our results indicate that early post-operative gains are largely maintained over time. Taken together, these findings suggest that our study provides meaningful reinforcement to the present body of evidence in this field.

There are limitations to this study. First, its retrospective design introduces potential selection bias. Second, radiological assessments were made at discrete time points and do not account for dynamic loading patterns during gait. Third, the sample size, although sufficient for statistical analysis, may limit the generalizability of the findings. Finally, the lack of a control group (e.g., isolated TKA without prior HTO) restricts direct comparative analysis.

CONCLUSION

While correction of knee varus deformity via HTO and TKA significantly improves associated ankle alignment, a residual varus deformity in the ankle persists. These findings underscore the importance of considering ankle biomechanics during surgical planning for knee deformity correction, particularly in staged procedures involving both HTO and TKA.

DECLARATIONS

Ethics Committee Approval: The study was approved by University of Health Sciences, Baltalimani Bone Diseases Training and Research Hospital Ethics Committee (No: 18/124, Date: 28/02/2024).

Informed Consent: Written informed consent had been obtained from all patients at the time of their initial surgical treatment regarding the use of their anonymized medical data for research purposes.

Conflict of Interest: The authors declare that there is no conflict of interest.

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Authorship Contributions: Concept – HB, SG; Design – HB; Supervision – FD; Fundings – HB, ÜSA, SG; Materials – HB, SG; Data collection &/or processing – ÜBA, ÜSA; Analysis and/or interpretation – FD, HB; Literature search – HB, SG; Writing – HB, SG; Critical review – FD.

Peer-review: Externally peer-reviewed.

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ORIGINAL ARTICLE

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Percutaneous Computed Tomography-Guided Excision of Osteoid Osteoma

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ABSTRACT

Objective: Osteoid osteoma (OO) is a common benign bone tumor typically affecting individuals under 25, characterized by localized pain responsive to non-steroidal anti-inflammatory drugs. Complete nidus removal is the primary treatment goal. While computed tomography (CT)-guided percutaneous excision is popular, trephine excision offers a cost-effective alternative, allowing histopathological confirmation. This study aimed to evaluate the clinical and radiological outcomes of CT-guided percutaneous nidus excision using a trephine.

Materials and Methods: This retrospective study included 24 patients (18 males and 6 females; mean age 15.3 years) diagnosed with OO who underwent CT-guided percutaneous nidus excision using standard orthopedic trephines. Pain severity (Visual Analog Scale [VAS]/faces pain scale), operation time, hospital stay, technical success (complete nidus removal), clinical success (pain resolution without recurrence), and complications were recorded. A paired t-test compared pre- and post-operative pain scores (significance at $p<0.05$).

Results: The mean pre-operative VAS score significantly decreased from 7.72±1.97 to 0.79±1.84 postoperatively ($p<0.001$). Technical success was achieved in 23/24 patients (96%). Clinical success was observed in 21/24 patients (87.5%), with three recurrences potentially linked to marking errors or larger nidus sizes. No intraoperative neurovascular injuries or fractures occurred. Post-operative complications included two deep infections and one delayed fracture. Histopathological confirmation of OO was obtained in 20/24 cases (83%).

Conclusion: CT-guided percutaneous trephine excision is an effective and safe treatment modality for OO, demonstrating high technical and clinical success rates with a low incidence of major complications and allowing for histopathological diagnosis. Further prospective studies with larger cohorts are warranted.

Keywords: Bone neoplasms, Computed tomography, Osteoid osteoma, X-ray

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INTRODUCTION

Osteoid osteoma (OO) is a benign osteoblastic bone tumor, accounting for approximately 11–12% of all benign bone tumors.[1,2] The lesion, known as the nidus, typically measures <2 cm in diameter and is surrounded by a reactive sclerotic zone.[3] OO most commonly affects individuals under the age of 25, and the clinical presentation often follows a characteristic pattern. Patients frequently report localized pain that intensifies at night or with activity,[4] and this pain generally exhibits a marked response to non-steroidal anti-inflammatory drugs.[5,6]

The primary objective in the treatment of OO is the complete removal or destruction of the nidus.[7] While various surgical options have been described, computed tomography (CT)-guided percutaneous excision has gained popularity due to its minimally invasive nature and reliable outcomes.[1] Among the percutaneous approaches, radiofrequency ablation (RFA) is widely used; however, it has several limitations, including its proximity to neurovascular structures, high cost, and the inability to obtain tissue for histopathological evaluation.[2,8,9] CT-guided trephine excision offers a cost-effective alternative that allows for both targeted removal and histopathological confirmation of the lesion. In addition, it can be performed using standard orthopedic instruments without requiring specialized equipment. The marking of the nidus is conducted in the CT suite, thereby reducing radiation exposure to the surgical staff.[1,10]

The present study aimed to examine the clinical and radiological outcomes of patients who underwent percutaneous nidus excision using a trephine following CT-guided nidus localization. We hypothesized that CT-guided percutaneous excision is an effective treatment modality for OO, providing high success rates with a low incidence of complications.

MATERIALS AND METHODS

Study Design and Setting

This retrospective study included patients diagnosed with OO who underwent CT-guided percutaneous nidus excision. Data collection was performed following approval from the institutional clinical research ethics committee (decision number: 2015/108). A total of 35 patients were screened between (insert time frame if available), and relevant clinical and radiological data were reviewed retrospectively.

Participants

Of the 35 patients initially evaluated, 11 were excluded due to one or more of the following: Previous surgical intervention for OO, follow-up duration <6 months, failure to attend follow-up visits, or refusal to participate. In addition, patients with comorbid conditions such as diabetes mellitus or immunodeficiency were excluded to ensure homogeneity of the study cohort. Ultimately, 24 patients (18 males and six females) were included. Informed consent – written or verbal – was obtained from all participants, and the study was conducted in accordance with the Declaration of Helsinki.

Radiological Diagnosis

The diagnosis of OO was based on clinical history and imaging findings. In patients presenting with typical symptoms, bilateral plain radiographs were initially obtained (Fig. 1). If solid cortical thickening was noted, thin-slice CT was subsequently performed. On CT, lesions demonstrating a lytic focus approximately 0.5–1 cm in diameter surrounded by reactive sclerosis were interpreted as indicative of the nidus.

Surgical Procedure

All patients received prophylactic intravenous cefazolin (20 mg/kg) approximately 30 min before the intervention. The procedure was performed in two stages using standard orthopedic tools: a trephine (Fig. 2), a guide wire, and a rechargeable drill (Bosch PSR Li-2). In the first stage, the nidus was localized and marked under CT guidance (Sensation 64; Siemens Medical Solutions, Forchheim, Germany) using a K-wire under local anesthesia (Fig. 3). In the second stage, performed in the operating room under regional or general anesthesia, the nidus was excised percutaneously using a trephine with a round-tipped edge (Fig. 4). Trephines of varying diameters (7 mm, 9 mm, and 11 mm) were selected based on the esti-

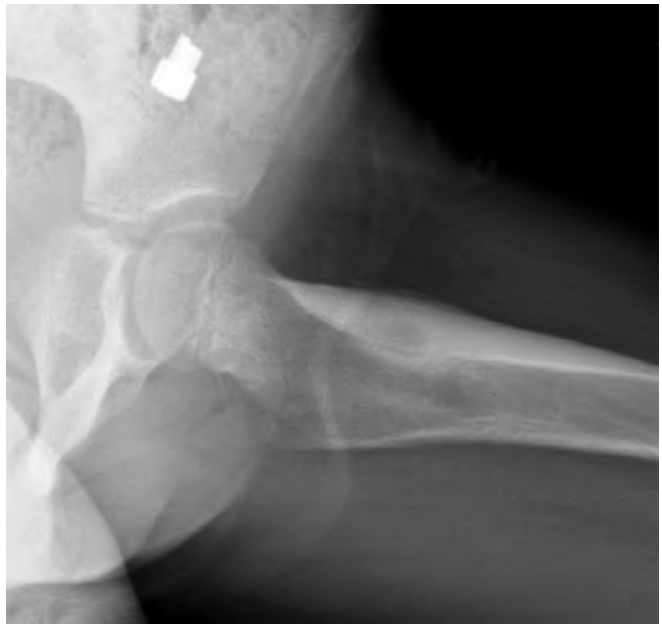

Figure 1. Pre-operative X-ray (lateral view) shows cortical thickening and nidus (arrow) localization.

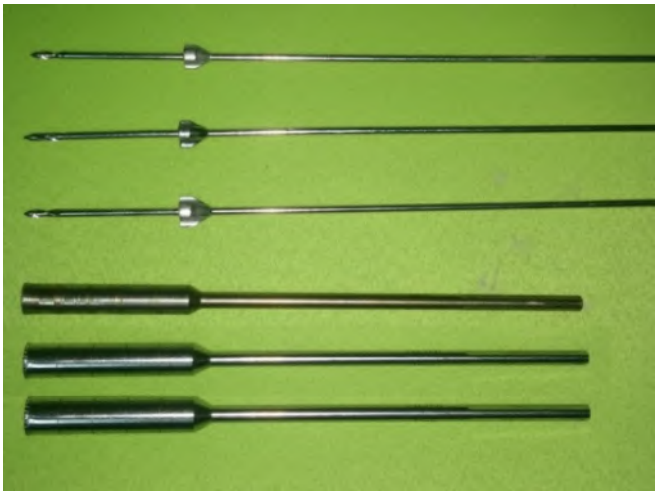

Figure 2. Trephine (round reamer) and guide wire of different diameters (7, 9, 11 mm) used in the procedure. For easy removal of the material in the reamer, there is a block on the guide wire with the width of the inner diameter of the trephine.

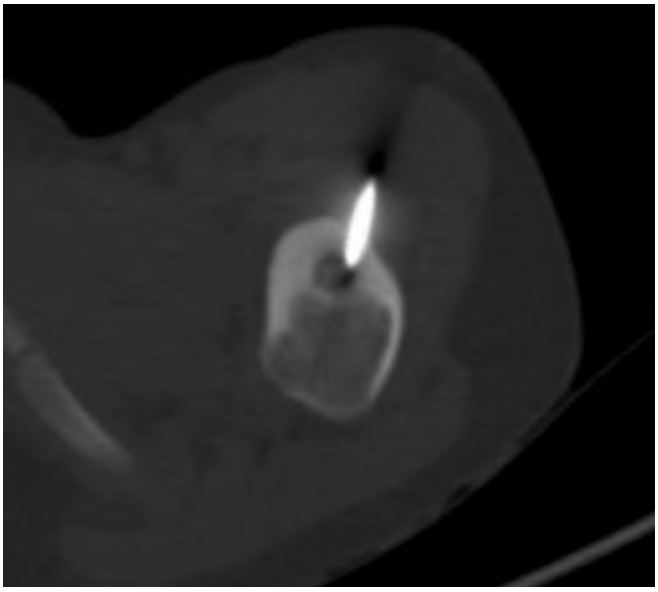

Figure 3. Nidus marked with K-wire under computed tomography guidance.

mated size of the nidus (Fig. 2), minimizing unnecessary resection. A low-speed drill was used to reduce thermal necrosis, and saline irrigation was applied for cooling. The drilled area was curetted to prevent leaving residual nidus tissue near the incision. All excised samples were sent for histopathological evaluation (Fig. 5).

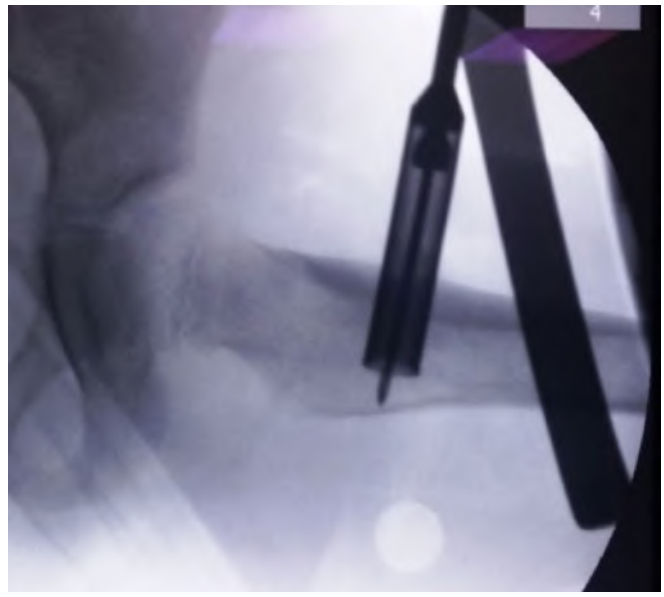

Figure 4. Intraoperative scope image: It covers the entire trephine nidus of the appropriate size, which is sent with a drill percutaneously over the guide wire.

Outcomes and Definitions

All patients underwent clinical assessment at their final follow-up. Demographic data (age and sex), affected extremity, follow-up duration, operation time, hospital stay, recurrence, and post-operative complications were recorded. Lesion location was categorized into subperiosteal, cortical, endosteal, or medullary types according to the classification by Kayser et al.[9] Pain severity was measured using the Visual Analog Scale (VAS) in 23 patients both preoperatively and postoperatively, where 0 indicated no pain and 10 indicated worst pain. In one pediatric patient (aged 4 years), pain was evaluated using the faces pain scale, which is particularly effective in children and individuals with communication difficulties.[11] Technical success was defined as complete nidus removal using trephine, whereas clinical success referred to complete pain resolution without recurrence during follow-up.[1] Post-operative radiological evaluations were conducted using plain X-rays (Fig. 6).

Ethical Considerations

All procedures were approved by the relevant institutional ethics committee (decision number: 2015/108), and patient consent was obtained in compliance with ethical standards.

Statistical Analysis

The statistical evaluation of the research data was performed using IBM Statistical Packages for the Social Sciences Statistics version 21.0 for Windows (Armonk, NY: IBM Corp.). Descriptive

statistics were used to summarize demographic and baseline characteristics, including age (mean±standard deviation, range), follow-up duration (mean±standard deviation, range), and the interval from symptom onset to diagnosis (mean±standard deviation, range). Categorical variables such as sex and lesion localization were presented as frequencies and percentages. A paired t-test was utilized to compare pre-operative and post-operative pain intensity scores as measured by the VAS, with statistical significance set at $p<0.05$. Procedural data, including the duration of nidus marking, surgical operation time, and hospital stay, were also summarized using descriptive statistics (mean±standard deviation, range). Technical and clinical success rates, as well as the incidence of post-operative complications and recurrence, were reported as percentages.

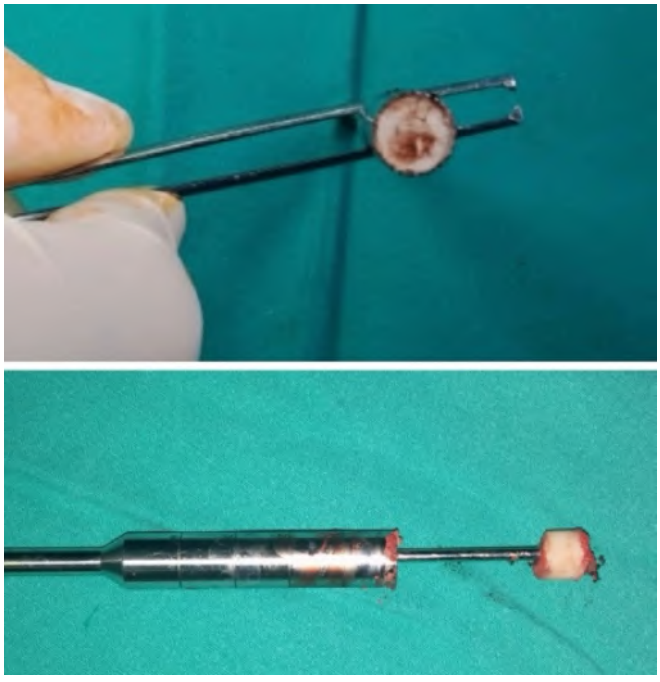

Figure 5. Nidus enbloced with a trephine. The nidus (arrow) is removed undamaged by the sclerotic tissue around it.

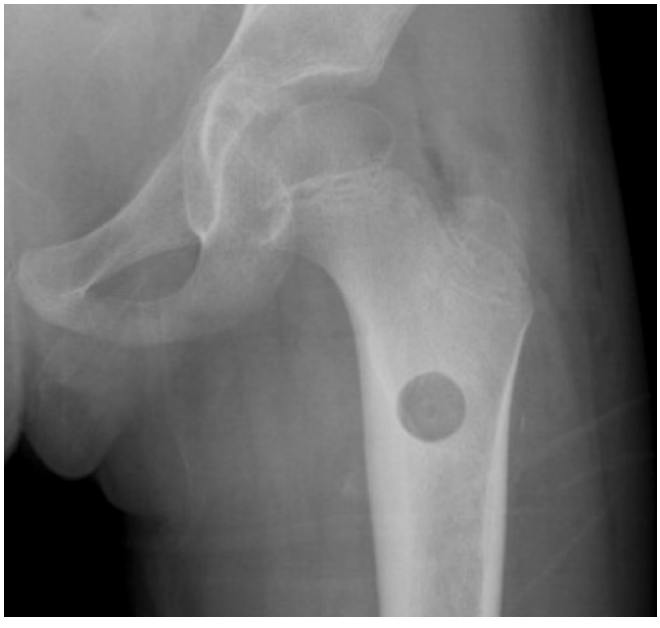

Figure 6. Post-operative direct X-rays show the extracted nidus.

RESULTS

Demographic and Baseline Characteristics

The mean age of the patients was 15.3 years (range: 4–27 years) (Fig. 7), and the mean follow-up duration was 18.2 months (range: 11–25 months). The mean interval from symptom onset to diagnosis was 11 months (range: 2–54 months). Lesion localization was as follows: tibia in 50% of patients (n=12), femur in 37.5% (n=9), fibula in 4.2% (n=1), metacarpals in 4.2% (n=1), and iliac crest in 4.2% (n=1) (Fig. 8).

Procedural Data

The mean duration for nidus marking under CT guidance was 14±3 min (range: 10–25 min), and the mean surgical operation time was 44.37±14.39 minutes (range: 25–90 min). The average hospital stay was 1.16±0.38 days (range: 1–2 days) (Table 1).

Clinical and Technical Outcomes

Pain intensity was assessed using the VAS. The mean pre-operative VAS score was 7.72±1.97 (range: 2–10), which significantly decreased postoperatively to 0.79±1.84 (range: 0–6) ($p<0.001$). Night pain associated with OO resolved completely within the first 24 h in 22 patients (92%). In one patient, com-

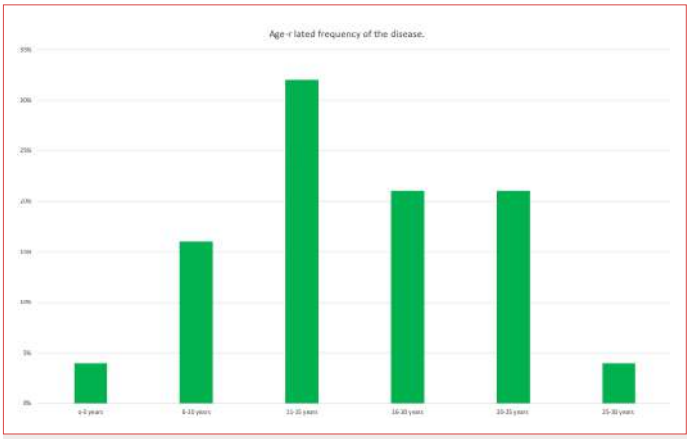

Figure 7. Age-related frequency of the disease.

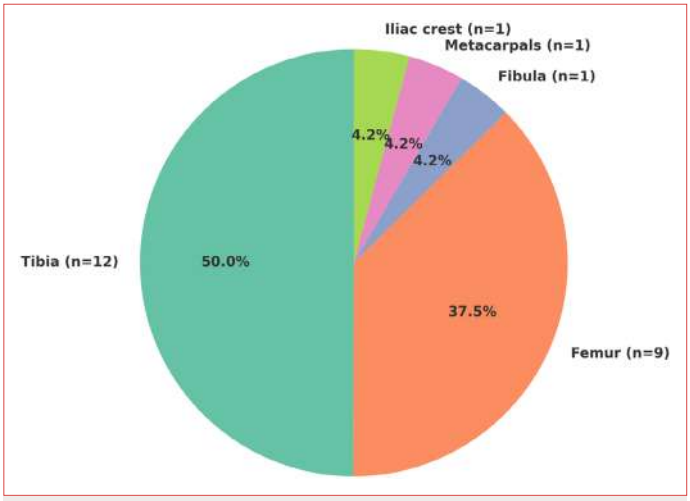

Figure 8. Distribution of lesions by anatomical location.

plete pain relief was achieved within 5 days. However, one patient continued to experience pain postoperatively. Upon review, this case was found to involve an inaccurate marking, resulting in incomplete nidus excision. Histopathological confirmation of OO was achieved in 83% of patients (n=20). Technical success – defined as complete nidus removal – was achieved in 23 out of 24 patients (96%). Clinically, successful outcomes – defined as the resolution of symptoms without recurrence – were observed in 21 patients (87.5%), whereas 3 patients (12.5%) experienced clinical failure. Among these, two patients exhibited recurrence: one with tibial diaphyseal involvement at 4 months and another with femoral diaphyseal involvement at 3 months postoperatively. Both cases had niduses with larger diameters (20 mm and 22 mm), suggesting incomplete excision due to instrument limitations.

Complications

No intraoperative complications, such as fractures or neurovascular injuries, were observed. One patient developed an incomplete tibial fracture during a sports activity 3 months postoperatively, which was managed conservatively with a long leg cast. The fracture united uneventfully after 2 months of immobilization. Deep surgical site infections occurred in two patients with tibial involvement. One case was treated with surgical debridement and antibiotics, whereas the other responded to antibiotic therapy alone. In both cases, the wounds healed without recurrence of infection until the final follow-up (Table 2).

Table 1. Patient demographics and operative data

Parameter	Mean±SD (range)	Notes
Mean age (years)	15.3 (4–27)	Patients' age range
Follow-up period (months)	18.2 (11–25)	Post-operative follow-up duration
Duration until diagnosis (months)	11 (2–54)	From onset of symptoms to diagnosis
CT marking time (minutes)	14±3 (10–25)	Time taken for CT-guided marking
Operation time (minutes)	44.37±14.39 (25–90)	Time from start to end of surgery
Hospital stay (days)	1.16±0.38 (1–2)	Days spent in the hospital post-surgery

CT: Computed tomography.

Table 2. Clinical outcomes and complications

Parameter	Mean±SD (Range)	Notes
Pre-operative VAS score	7.72±1.97 (2–10)	Indicates initial pain severity
Post-operative VAS score	0.79±1.84 (0–6)	Significant reduction in pain ($p<0.001$)
Clinically successful outcomes (%)	87.5% (n=21)	Patients with complete pain resolution
Clinically unsuccessful Outcomes (%)	12.5% (n=3)	Incomplete nidus removal or recurrence
Recurrence rate	8.3% (n=2)	Found in larger nidus sizes (20–22 mm)
Complications	3 cases	1 fracture, 2 infections

VAS: Visual analog scale.

DISCUSSION

This study demonstrated that CT-guided percutaneous excision using a trephine exhibited high technical (96%) and clinical (87.5%) success rates in the management of OO. Furthermore, the histopathological diagnosis rate achieved with this method was 83%, and the incidence of complications was notably low. Specifically, a significant reduction in post-operative pain scores (VAS score: from 7.72 to 0.79) was observed. These findings suggest that CT-guided percutaneous excision represents an effective and safe treatment modality for OO.

The primary objective in the surgical treatment of OO is the marginal or wide en bloc excision of the lesion, which can be accomplished through either open or closed techniques.[12] Open surgery is associated with a higher risk of bone loss and complications, with literature reporting complication rates ranging from 25% to 45%. Consequently, the preference for open surgery has diminished in favor of less invasive approaches.[3] Percutaneous techniques result in less bone loss and facilitate access to anatomically challenging regions. Minimally invasive methods such as RFA, laser photocoagulation, and CT-guided percutaneous excision are frequently favored, wherein the nidus is coagulated and excised using chemical or physical agents.[13] One percutaneous approach involves marking and drilling the nidus under CT guidance. This procedure can expose the operating room staff, patient, and physician to prolonged radiation.[9,14] To mitigate radiation exposure, Fenichel et al.[15] conducted a study involving 18 cases, utilizing a specifically designed cannulated trephine for en bloc excision of the nidus, which resulted in an increased rate of pathological diagnosis. Consistent with the aim of lower cost and high pathological diagnosis rates, we also employed this method, utilizing cannulated trephines of varying diameters for the excision of niduses of different sizes.

The principal complaint of patients with OO is pain.[16,17] Clinical improvement is typically observed rapidly and significantly following the excision of the nidus. In a study by Ofluoğlu et al.,[18] the pre-operative mean VAS score was reported as 7.9±1.2, whereas the post-operative VAS score was 0.3±0.6, with pain resolution occurring on average within 4 days. However, this duration can occasionally extend up to 1 month. Prolonged pain may indicate incomplete excision of the nidus.[19] In our study, rapid and significant pain relief was observed in all patients except one who experienced a marking error. Postoperatively, pain was completely resolved within the first 24 h in 22 cases (92%), whereas in one case, complete resolution took 5 days. Retrospective examination revealed that the patient with persistent pain had undergone incomplete excision due to a marking error. Clinically successful outcomes were achieved in 21 patients (87.5%), with 3 patients (12.5%) experiencing unsuccessful outcomes, primarily attributed to marking errors.

A significant advantage of the percutaneous excision method is its capacity to provide sufficient and reliable tissue samples for pathological examination. The literature suggests that ablation techniques, particularly RFA, have been inadequate for obtaining pathological diagnoses.[2,8] As methods such as RFA aim to destroy the nidus through coagulation, a solid sample for histological evaluation may not be obtained. Conversely, CT-guided percutaneous excision ensures complete removal of the nidus, leading to a higher rate of reliable pathological diagnoses.[20] The agreement rate for pathological diagnoses using ablation techniques is reported to range from 30% to 60%.,[20,21] whereas this rate varies from 83% to 100% for the CT-guided percutaneous excision method.[8,22] In our study, a significant majority (83%) of cases utilizing this method achieved histopathological confirmation, supporting its reliability. The failure to obtain a diagnosis during pathological examination may result from mechanical damage to the nidus during excision or thermal effects caused by the rotation of the trephine.

Recurrence rates for OO vary considerably depending on the treatment modalities employed. Open surgery is less frequently preferred today due to its high recurrence rates, reported in the literature to range from 4.5% to 23%.[23] In the study by Yang et al.,[22] the recurrence rate for conventional open surgery was significantly higher than that for CT-guided minimally invasive surgery. Furthermore, the minimally invasive method resulted in shorter hospital stays, less bone loss, and reduced surgical duration. Percutaneous ablation methods, particularly RFA, have been shown to significantly lower recurrence rates. Success rates for percutaneous RFA treatments are reported to be between 88% and 95%, with recurrence rates below 5%.[24-27] However, some studies have indicated higher than expected recurrence rates; for instance, Shields et al.[25] reported a rate of 16.3%. The use of RFA under CT guidance allows for precise targeting of the nidus, contributing to better outcomes and lower recurrence rates.[3] In a study by Lindquester et al.,[26] the failure rates for percutaneous RFA and cryoablation were found to be similar (averaging 5.6%), and a second ablation successfully treated 71.2% of recurrences. Similarly, low recurrence rates (0–12.5%) have been reported for CT-guided percutaneous excision.[9,28] In our study, clinically successful outcomes were achieved in 21 patients (87.5%), whereas 3 patients (12.75%) experienced post-operative recurrence. Our retrospective analysis identified a marking error in one patient, and the recurrences in the other two patients were likely due to the larger diameters of their niduses (20 mm and 22 mm). Considering that the maximum diameter of the trephines we used was 11 mm, complete excision may not have been possible, and adequate curettage may not have been performed after excision. In addition, if the marking coincided with the periphery of the

nidus rather than the center, the nidus may not have been completely removed. Although the success rates of our method are comparable to the widely used RFA, trephine excision is considerably more economical.[29]

Perioperative fractures, prolonged hospital stays, and delays in clinical improvement are the main complications associated with open surgery. Complication rates for RFA treatments are reported to range from 0% to 15%,[24,30] and the long-term side effects remain poorly understood.[13,14] In a study by Sans et al.,[31] two of the 38 patients treated with RFA developed pathological fractures postoperatively, and one case experienced chronic osteomyelitis. For CT-guided trephine percutaneous excision, complication rates range from 0% to 24%, with reported complications including post-operative fractures, hematomas, infections, nerve damage, and osteomyelitis. Raux et al.[32] reported femoral fractures in two patients, yielding an average complication rate of 4.7%. In addition, a study by Reverte et al.[29] evaluating 54 cases found that major complication rates and technical problems were more frequently observed in RFA cases compared to those treated with CT-guided percutaneous excision. In our study, deep infections occurred in two cases, and one patient developed a fracture 3 months after surgery. The infections were treated with appropriate antibiotic therapy and wound care, while the fracture was managed with plates and screws.

This study has several limitations. First, its retrospective design and relatively small sample size (n=24) may restrict the generalizability of the findings. Future studies with larger cohorts and longer follow-up periods are needed to provide more robust data regarding the long-term outcomes and recurrence rates associated with CT-guided percutaneous trephine excision. Second, all procedures were performed at a single center by an experienced orthopedic team, which may introduce selection bias; results may differ when performed by surgeons at other centers or with varying levels of expertise. In addition, while the study focused on clinical success and radiological outcomes, it did not comprehensively assess patient-reported quality of life and functional recovery, which are important for understanding the overall impact of the treatment. Finally, the absence of direct comparisons with other treatment methods, such as RFA, limits the ability to definitively assess the superiority of one technique over another. Future prospective studies are essential to validate the comparative efficacy and safety of these treatment methods.

CONCLUSION

CT-guided percutaneous excision with a trephine is an economical and reliable method that offers high success rates and a low risk of complications and facilitates histopathological diagnosis in the treatment of OO. This method is advantageous in terms of diagnostic accuracy, particularly when compared to other minimally invasive methods such as RFA. However, limitations such as the retrospective design and small sample size highlight the necessity for prospective studies with larger cohorts in the future. Furthermore, randomized controlled trials comparing this method with other minimally invasive techniques can provide more precise results regarding the effectiveness and safety of treatment options.

DECLARATIONS

Ethics Committee Approval: The study was approved by Dicle University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee (No: 2015/10, Date: 23/01/2015).

Informed Consent: Written or verbal - was obtained from all participants.

Conflict of Interest: The authors declare that there is no conflict of interest.

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Use of AI for Writing Assistance: Artificial intelligence-supported technologies were not used in our study.

Authorship Contributions: Concept – MAÇ, CA; Design – MAÇ; Supervision – CA, AD; Fundings – CA, AD; Materials – YM, RA; Data collection &/or processing – ESY, YM; Analysis and/or interpretation – MAÇ, YM; Literature search – RA, ESY; Writing – MAÇ, ESY; Critical review – RA, AD.

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CASE REPORT

European Archives of Medical Research

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Pediatric Cervical Chondromesenchymal Hamartoma: Case Report of a Rare Tumor

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ABSTRACT

Cervical chondromesenchymal hamartoma (CMH) is a rare, benign tumor that typically occurs in the soft tissues of the neck. We present a case of a 4-year-old male child who presented with a slowly expanding, painless left paramedian neck mass. Imaging studies revealed a well-circumscribed, lobulated solid lesion with a heterogeneous appearance, extending from the left thyroid lobe to the upper mediastinum. The mass was completely excised and histopathologically diagnosed as a CMH. This case highlights the importance of considering this rare entity in the differential diagnosis of a neck mass in a child. The imaging characteristics and histopathological findings are discussed, and the treatment and outcome are reported. This case report adds to the limited literature on cervical CMH in children and emphasizes the importance of complete surgical excision as the treatment of choice.

Keywords: Chondromesenchymal hamartoma, Computerized tomography, Magnetic resonance imaging, Neck

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INTRODUCTION

Hamartomas are abnormal growths of cells and tissues that originate in the same organ or tissue where they are found. Histologically, this entity is composed of a combination of immature connective tissue (mesenchymal) and cartilage cells.

Hamartomas of the head and neck are rather uncommon, despite the possibility of presentation in any part of the body. They have been discovered in a number of places, including the endotracheal and endobronchial areas, hypothalamus, dermis, nose, lingua, thyroid gland, and larynx.[1]

Here was a report of a histopathologically proven chondromesenchymal hamartoma (CMH) located in the cervical region adjacent to the left lobe of the thyroid gland.

CASE PRESENTATION

A 4-year-old male child presented to the pediatric surgery clinic in our hospital with a slowly expanding painless left paramedian neck mass. Medical history was unremarkable, and there was no history of drug usage. On physical examination, the patient had a painless mobile mass on the left side of the neck (Fig. 1).

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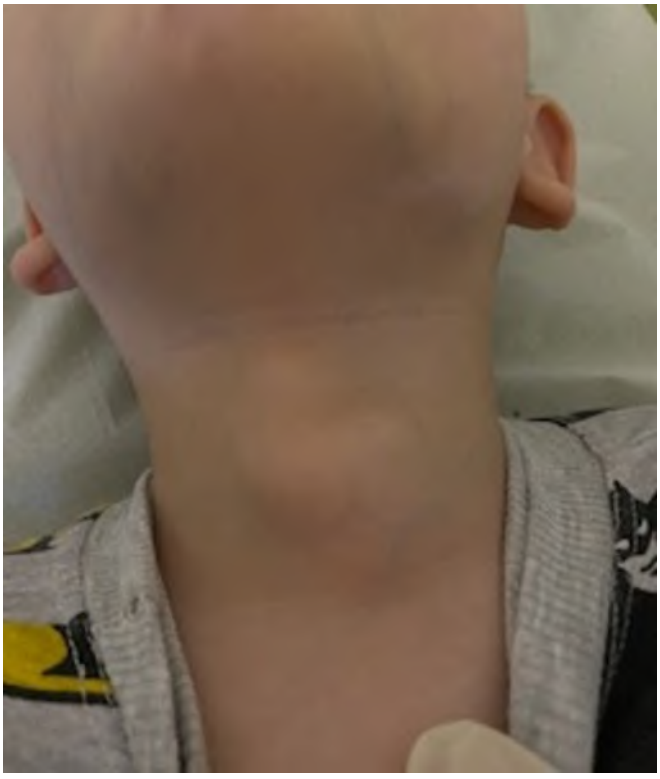

Figure 1. A 4-year-old patient with a left paramedian mass in the neck.

Ultrasound examination revealed a lobulated, contoured solid mass lesion adjacent to the left thyroid lobe, hypoechoic compared to the gland parenchyma, with no vascularization. Computed tomography (CT) and magnetic resonance examinations were performed for optimal evaluation of the lesion borders and neighborhood.

CT examination revealed a 31×48×46 mm, well-circumscribed, lobulated solid lesion with a heterogeneous appearance starting from the localization of the left thyroid lobe and extending toward the upper mediastinum in the paramedian neck (Fig. 2). The trachea was deviated to the right due to mass effect. There was no destruction in the adjacent fatty and bony structures. The right thyroid lobe was normal appearing, but the left lobe could not be differentiated separately.

On magnetic resonance imaging (MRI), a lobule contoured mass lesion was observed, which was hypointense on T1-weighted images, heterogeneously hyperintense on T2-weighted images, showing only thin wall contrast uptake on contrast-enhanced series, and no diffusion restriction on diffusion-weighted images (Figs. 3-6). The lesion was adjacent to the main vascular structures and extended to the upper mediastinum. No pathological lymph nodes were observed in the cervical chains.

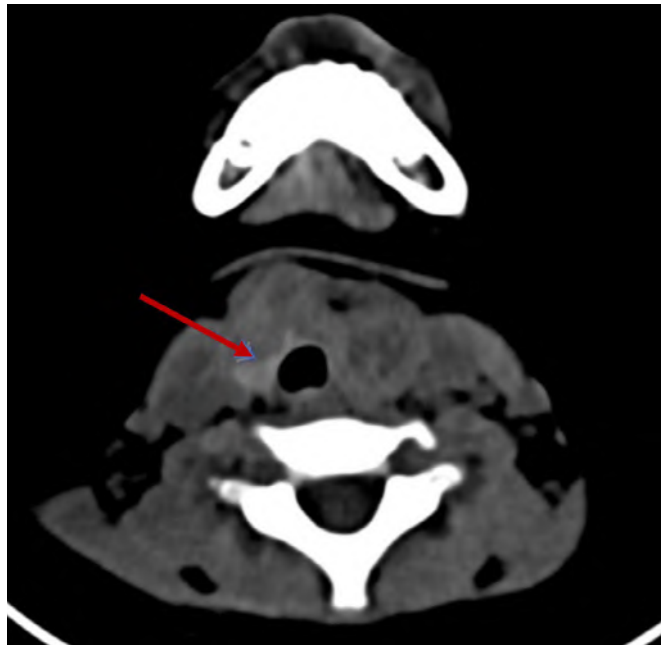

Figure 2. Non-contrast computed tomography scan shows a hypodense, heterogeneous solid mass at the level of the thyroid gland. The right lobe can be differentiated from the mass (arrow).

The patient was operated (Fig. 7).

The lesion, which was found to be anterior to the isthmus and left lobe of the thyroid gland, was completely excised and pathologically diagnosed as CMH (Figs. 8-10).

DISCUSSION

CMHs are rare, benign lesions characterized by disordered proliferation of mesenchymal and cartilaginous tissues. While most commonly reported in the sinonasal cavity as nasal CMHs (NCMHs), their occurrence in atypical locations, such as the cervical region or ectopic thyroid tissue, remains exceedingly rare.[2] Our case presents a 4-year-old male child with a slowly expanding, painless left paramedian neck mass, which was ultimately diagnosed as a cervical CMH. The anatomical presentation of CMHs varies significantly. One of the reported neonatal CMH cases developed within ectopic thyroid tissue.[3] In our patient, the mass arose adjacent to the left thyroid lobe, a feature shared with neonatal cervical CMH described by Yang et al.,[4] causing tracheal deviation. This feature highlights the potential for CMHs to mimic thyroid neoplasms or teratomas radiologically, necessitating histopathological confirmation. In contrast, nasal CMHs that have been reported predominantly involve the nasal cavity, presenting with obstructive symptoms such as nasal congestion or epistaxis.[2,5] Despite these differences, histopathology remains consistent across anatomical sites, with hyaline

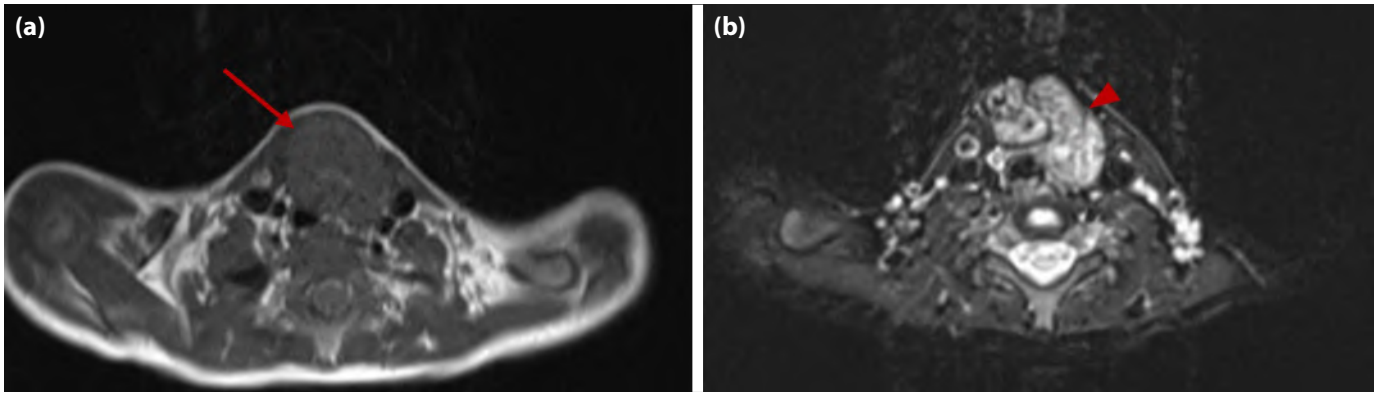

Figure 3. On magnetic resonance examination, the lesion was isointense with adjacent muscle planes in axial T1A **(a)** series and heterogeneous hyperintense signal in fat-suppressed axial T2A series **(b)**.

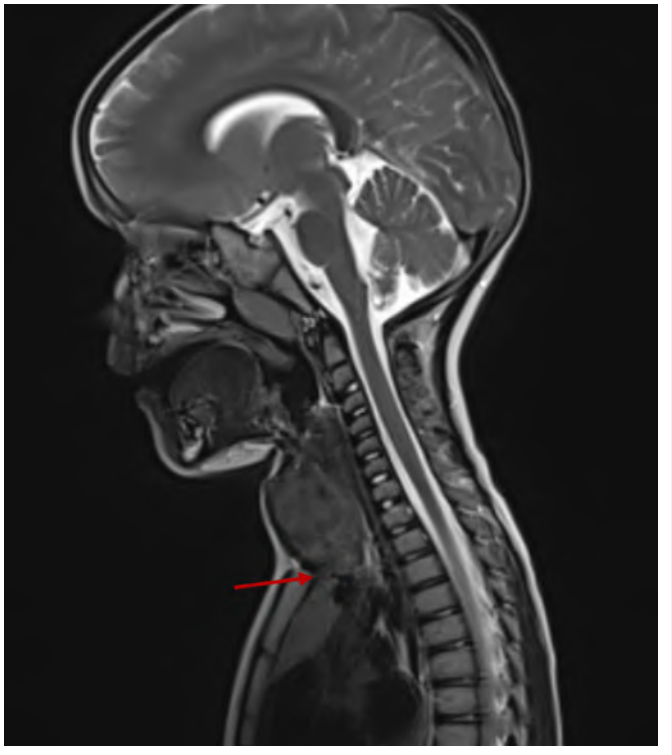

Figure 4. Sagittal T2-weighted images show extension of the lesion toward the upper mediastinum.

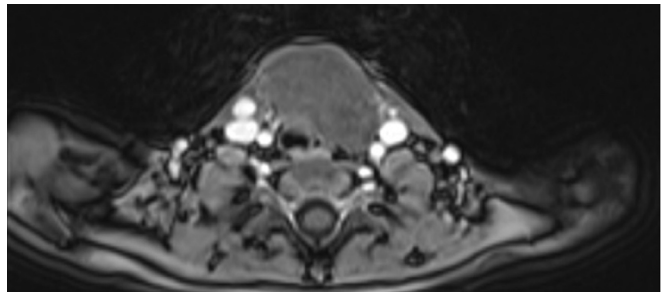

Figure 5. On fat-suppressed axial T1-weighted images, the lesion showed no contrast enhancement except for thin-walled contrast enhancement.

cartilage nodules, spindle cell stroma, and absence of cytologic atypia serving as diagnostic hallmarks.[3,6]

Emerging genetic insights suggest a potential link between CMHs and somatic DICER1 mutations, particularly in nasal cases. In one study, hotspot mutations were identified in exon 25 of DICER1 in 55.6% of NCMH cases, aligning these lesions with the DICER1 tumor family.[5] While genetic testing was not performed in our cervical case or the neonatal ectopic thyroid CMH case,[3] this molecular association raises questions about shared pathogenic mechanisms across anatomical subtypes. Notably, DICER1-mutated tumors often arise in pediatric populations, consistent with the age distribution of CMHs.[5,6] CMHs exhibit a strong pediatric predominance, as evidenced by our case, the neonatal ectopic thyroid CMH,[3] and the neonatal cervical CMH.[4] However, adult NCMH cases were also reported (up to 55 years), demonstrating that these lesions are not exclusive to early childhood.[5] Regardless of age, complete surgical excision remains the cornerstone of management. In our patient, total resection resulted in symptom resolution without recurrence at 6-month follow-up – an outcome mirrored in both neonatal and adult cases.[3,5] This consistency reinforces the benign nature of CMHs but underscores the need for meticulous pre-operative imaging (MRI/CT) to delineate tumor margins, particularly in complex cervical or mediastinal locations.[2,7]

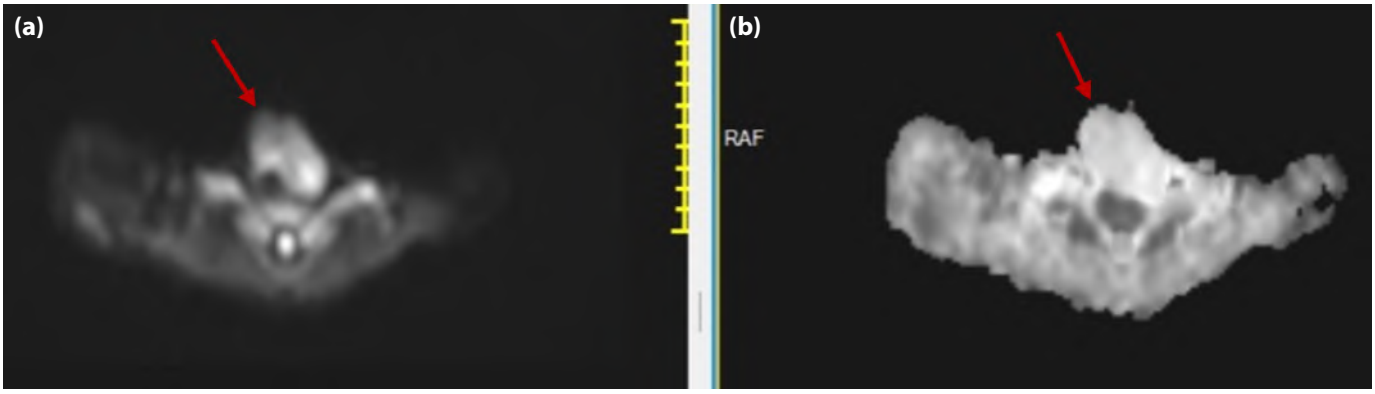

Figure 6. Diffusion **(a)** and ADC **(b)** images show no diffusion restriction of the lesion.

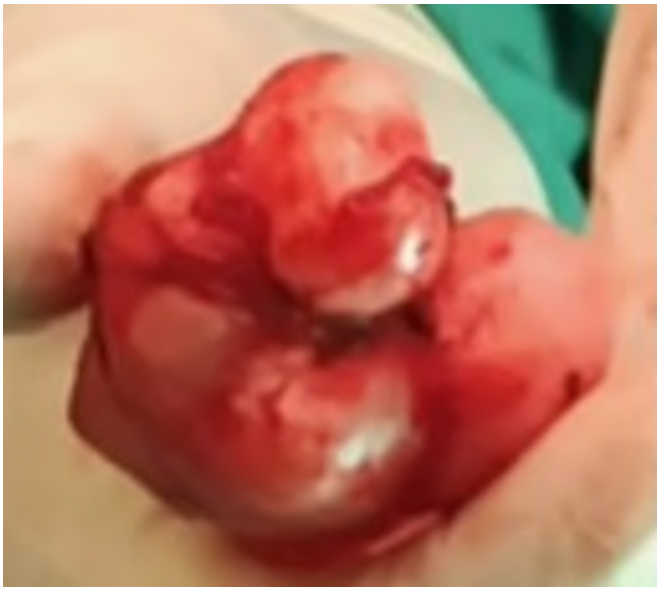

Figure 7. Macroscopic view of the total excised lesion.

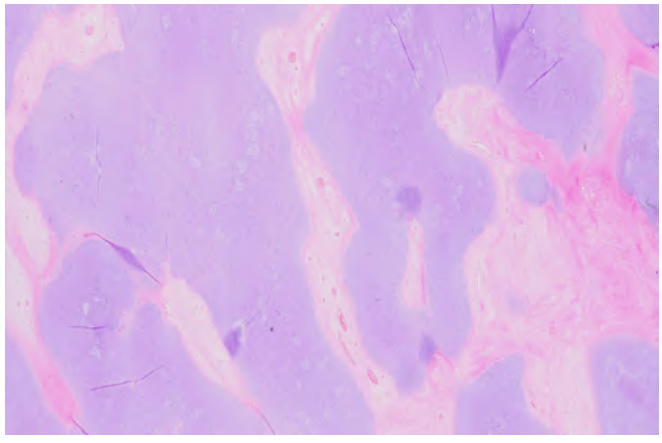

Figure 8. Pathological characteristics of the chondromesenchymal hamartoma (HE staining) in case. Hyaline cartilage with endochondral ossification surrounds.

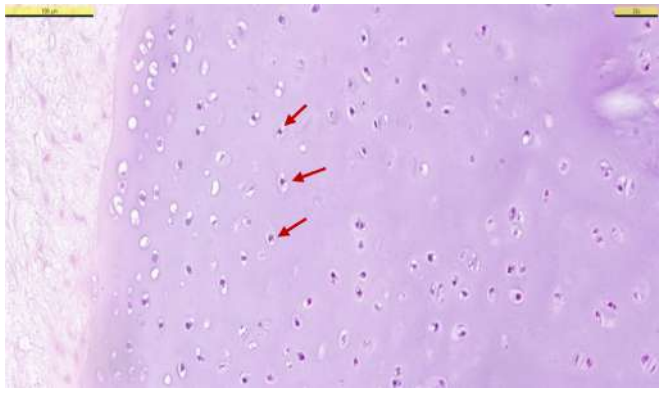

Figure 9. Chondrocytes in lacunae, arranged diffusely. Cellular atypia, mitotic figures, and cellularity were not seen.

The rarity of CMHs increases their susceptibility to misdiagnosis. In our case, imaging initially suggested a thyroid neoplasm, while according to the literature, 44% of NCMHs were misclassified preoperatively as nasal polyps or cartilaginous lesions.[5] Similarly, previous studies emphasized the non-specific radiological features of their neonatal ectopic thyroid CMH.[3] Key differentials for cervical CMHs include teratomas, rhabdomyosarcoma, and lymphatic malformations, all requiring distinct management approaches.[1,7]

Histopathology remains critical for definitive diagnosis, as it reveals the characteristic admixture of cartilage, spindle cells, and the absence of malignancy.[3,6]

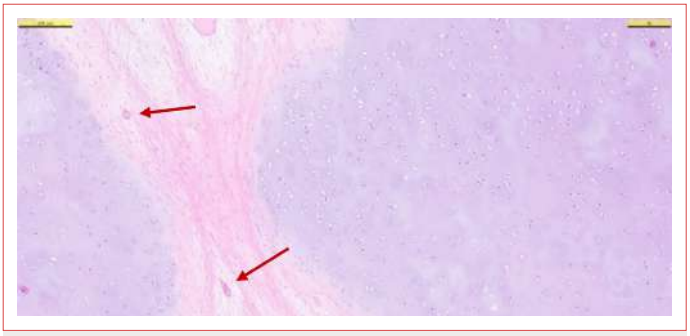

Figure 10. A number of mesenchymal spindle-shaped cells interwoven with multilobulated hyaline cartilage.

Congenital and developmental anomalies may contribute to CMH pathogenesis. The neonatal ectopic thyroid CMH exemplifies this, as aberrant thyroid migration likely provided a nidus for hamartomatous growth.[3] While our patient had no congenital abnormalities, this association highlights the importance of prenatal imaging and postnatal vigilance in neonates with neck masses. The role of hormonal or embryonic factors, such as the progesterone receptor expression noted in a scalp CMH, warrants further exploration.[8]

CONCLUSION

Our case highlights the importance of considering CMH in the differential diagnosis of a neck mass in a child. The imaging characteristics and histopathological findings in our case are consistent with this diagnosis, and the tumor was successfully treated with complete surgical excision.

DECLARATIONS

Ethics Committee Approval: This is a single case report, and therefore ethics committee approval was not required in accordance with institutional policies.

Informed Consent: Informed consent was obtained from the parents of the child.

Conflict of Interest: The authors declare that there is no conflict of interest.

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Authorship Contributions: Concept – ÖA, DB; Design – ÖA, DB; Supervision – AK, OY, ÖY; Materials – OY, AK; Data collection &/or processing – OY, AK, ÖY; Analysis and/or interpretation – ÖA, DB; Literature search – ÖA, DB; Writing – ÖA, DB; Critical review – ÖY.

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CASE REPORT

European Archives of Medical Research

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Eur Arch Med Res 2025;41(2):117–121

Autologous Cartilage Transfer from Carpal Bones for the Treatment of Osteochondral Defect in Distal Tibial Pilon Fracture: A Rare Case Report

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ABSTRACT

High-energy tibial pilon fractures frequently lead to complex intra-articular injuries, metaphyseal bone loss, and articular surface defects, posing significant challenges in surgical reconstruction. Osteochondral defects, in particular, may progress to osteoarthritis (OA) if not properly addressed. We present a rare case of a 25-year-old male who sustained multiple fractures, including a complex intra-articular distal tibial fracture with osteochondral and metaphyseal bone loss. Due to concurrent wrist trauma requiring arthrodesis, autologous cartilage from resected proximal carpal bones was harvested and used to reconstruct the tibial articular defect. The metaphyseal defect was filled with autologous iliac crest bone graft, and internal fixation was achieved via anteromedial and lateral plating. The patient was followed for 2 years. No post-operative complications, such as infection or wound problems, were observed. Functional evaluation using the Foot and Ankle Outcome Score revealed significant improvements in all subscales, with no range of motion limitations in the ankle. Autologous cartilage transfer from carpal bones may offer a viable alternative for treating distal tibial osteochondral defects, especially in cases where simultaneous wrist arthrodesis is indicated. This approach provides a novel solution for joint surface reconstruction and may prevent long-term complications such as post-traumatic OA.

Keywords: Bone defect, Cartilage transfer, Fracture, Pilon, Plafond

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INTRODUCTION

The surgical treatment of tibial plafond fractures was first described by Rüedi and Allgöwer.[1] These injuries are typically associated with high-energy mechanisms such as axial loading or shearing forces. They can result in multiple metaphyseal fragments, bone loss, displaced intra-articular comminution or defects, and severe soft-tissue injuries. The fibula is also commonly fractured in high-energy trauma. Approximately 10–28% of these fractures are open injuries.[2]

Most surgeons recommend anatomical reconstruction of the joint surface, restoration of tibial alignment, and stabilization of the fracture to facilitate bone healing.[3] Osteochondral defects caused by intra-articular comminution may lead to progressive degeneration of the articular cartilage and eventually osteoarthritis due to the inability to achieve a sufficiently smooth joint surface.[4,5] In pilon fractures, complete articular injuries with multiple intra-articular fragments and metaphyseal comminution account for 54–76% of all cases.[6,7]

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Over the past two decades, the treatment strategy for pilon fractures has shifted toward a two-stage surgical approach, allowing for soft-tissue recovery before definitive fixation.[7,8] Despite advancements, infection rates during reconstructive attempts reported in the literature range from 5% to 19%.[7-9] Even in the absence of infection, patients – particularly those with type C3 injuries – struggle with stiffness (35%), persistent swelling (29%), and post-traumatic arthritis (39%).[6,9]

Challenges in managing these injuries include filling metaphyseal bone defects and supporting a fragmented joint surface during reconstruction. Options available to orthopedic surgeons include plate fixation with augmentation using cancellous autografts, structural allografts, demineralized bone matrix, and calcium-based cements.[10-12] However, in cases where the joint surface is too fragmented or defective to be reconstructed, primary arthrodesis or secondary arthrodesis after post-traumatic arthritis is recommended.[13]

In this case report, we present the use of an autologous cartilage graft harvested from the wrist to treat a distal tibial osteochondral lesion (OCL), demonstrating its feasibility in appropriately selected cases.

CASE PRESENTATION

Written informed consent was obtained from the patient for the scientific use of their data presented in this study. A 25-year-old male patient presented with multiple injuries sustained from a high-energy fall 1 month prior. His injuries included a left wrist fracture-dislocation, left femoral intertrochanteric fracture, left ankle fracture-dislocation, right medial malleolar fracture, fractures of the proximal bases of the right second and third metatarsals, sacral fracture, and pubic diastasis.

Initial emergency treatment at an outside facility involved external fixation for the left ankle fracture-dislocation, proximal femoral nailing for the left femoral fracture and screw fixation for the right medial malleolus. Following stabilization of his general condition, the patient was referred to our institution for further management.

Orthopedic evaluation and radiological imaging revealed additional fractures of the left distal radius, scaphoid, and lunate. Therefore, proximal row carpectomy and wrist arthrodesis were scheduled. For the left ankle fracture-dislocation, a staged procedure was planned, including removal of the external fixator, medial and lateral plating, autologous iliac crest bone grafting for the metaphyseal defect, and cartilage grafting using autologous cartilage harvested from the resected proximal carpal bones.

Under general anesthesia, with the patient in the supine position and a thigh tourniquet applied, an anteromedial approach was used to reduce the fracture. An osteochondral defect measuring approximately 2×0.5 cm was identified on the articular surface (Fig. 1). An appropriately sized cartilage graft, harvested from the proximal carpal bones, was shaped and secured to the defect site using a single Kirschner wire (Fig. 2). Autologous cancellous bone graft was obtained from the right iliac crest and placed into the metaphyseal defect. Internal fixation was completed with an anteromedial plate, followed by anatomical plating of the lateral malleolus through a lateral approach (Fig. 3). The wounds were appropriately closed and dressed. A short leg splint was applied. Post-operative radiographs of the wrist and ankle were obtained (Figs. 4-7).

The patient was followed for a total of 2 years. Scheduled follow-ups occurred at 2 weeks, 1 month, 3 months, 6 months, 1 year, and 2 years. The left lower extremity was kept non-weight-bearing for 6 weeks. Ankle rehabilitation exercises were initiated 1 week postoperatively following splint removal. Partial weight-bearing began at 6 weeks and was gradually increased. Rehabilitation of the left wrist and hip also began in the early post-operative period. Sutures were removed at 2 weeks, and low-molecular-weight heparin was administered for 4 weeks postoperatively.

No wound complications or infections were noted during follow-up. The patient showed significant improvement in pain, as indicated by the Visual Analog Scale. At the final evaluation,

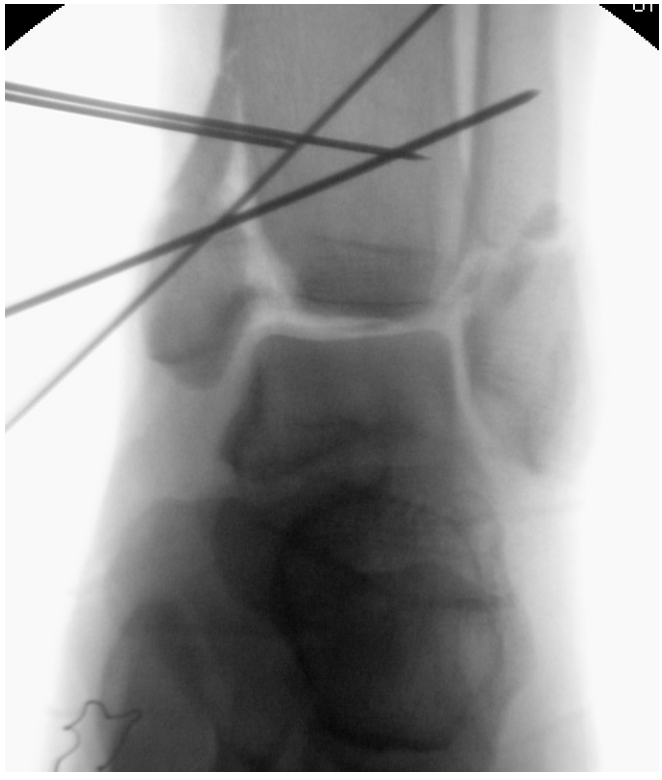

Figure 1. Fluoroscopic view after reduction shows the chondral and metaphyseal bone defect.

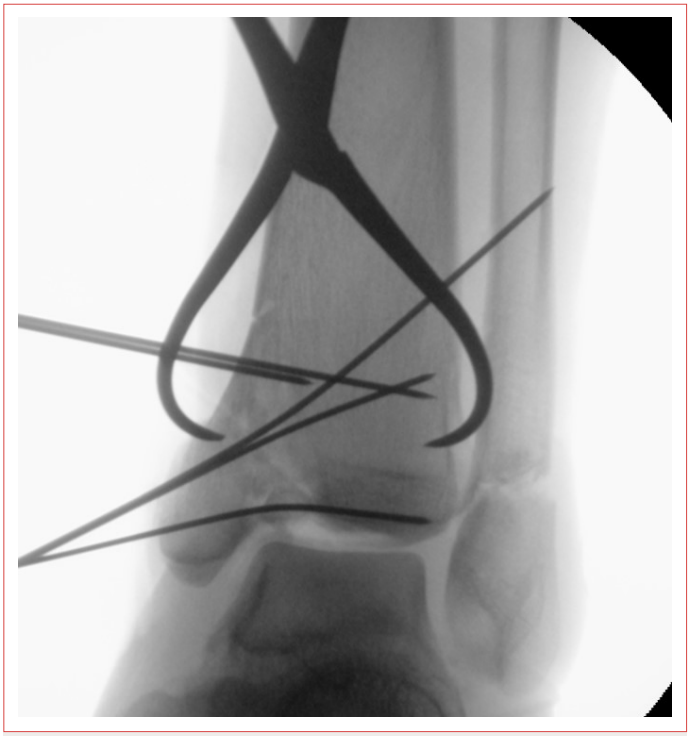

Figure 2. Fracture fixation after graft placement using K-wires and a Weber clamp.

Foot and Ankle Outcome Score (FAOS) subscales were as follows: Pain 87.1, Symptoms 85.1, Quality of Life 88.9, Sports and Recreation 78.5, and General Health 79.9. No range of motion limitation of the ankle was observed.

DISCUSSION

The surgical management of metaphyseal bone loss and osteochondral defects resulting from high-energy distal tibial plafond fractures remains a significant challenge. In most cases, the defects occur in the metaphyseal region of the fracture. Compared to metaphyseal bone loss, chondral defects are encountered less frequently. According to Lauge-Hansen classification, chondral damage is more commonly seen in supination-adduction type injuries, particularly due to impaction in the anteromedial tibia, where OCLs occur more frequently.

In a systematic review by Martijn et al.,[14] the incidence of OCLs detected immediately after trauma was reported to be 45.1%, with 16.6% of these involving the tibial plafond. Da Cunha et al.[15] found that patients with chondral lesions had significantly worse scores in all subdomains of the FAOS – including pain, symptoms, daily activities, sports and recreation, and quality of life – compared to patients without chondral lesions. Furthermore, patients with full-thickness lesions had significantly lower post-operative quality of life scores compared to those without full-thickness damage.

Figure 3. Fluoroscopic image showing fracture fixation and chondral graft stabilization with a K-wire.

While metaphyseal defects are generally treated with autografts from the iliac crest or structural allografts, chondral defects – such as in our case – may benefit from cartilage grafting techniques. Due to the complexity and fragmentation of articular cartilage, suitable donor sites for autografts are limited. In our patient, wrist arthrodesis was already planned, which allowed us to harvest autologous cartilage from the resected carpal bones. This represents a rare and unique approach to treating a distal tibial osteochondral defect.

The retrospective nature of this study, and the rarity of simultaneous wrist arthrodesis and ankle chondral defect in the same patient, are limitations to be acknowledged. However, autologous cartilage grafting using carpal bones should be considered a viable alternative in select cases.

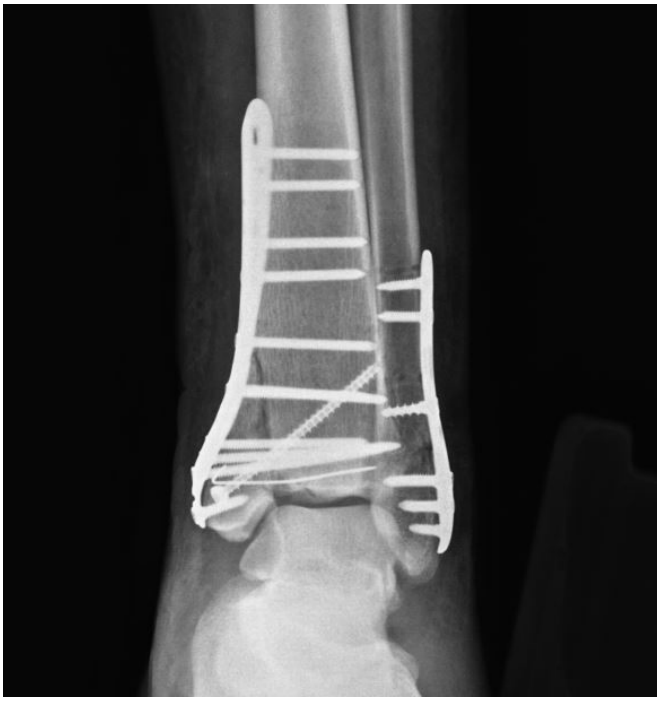

Figure 4. Post-operative anteroposterior X-ray of the ankle.

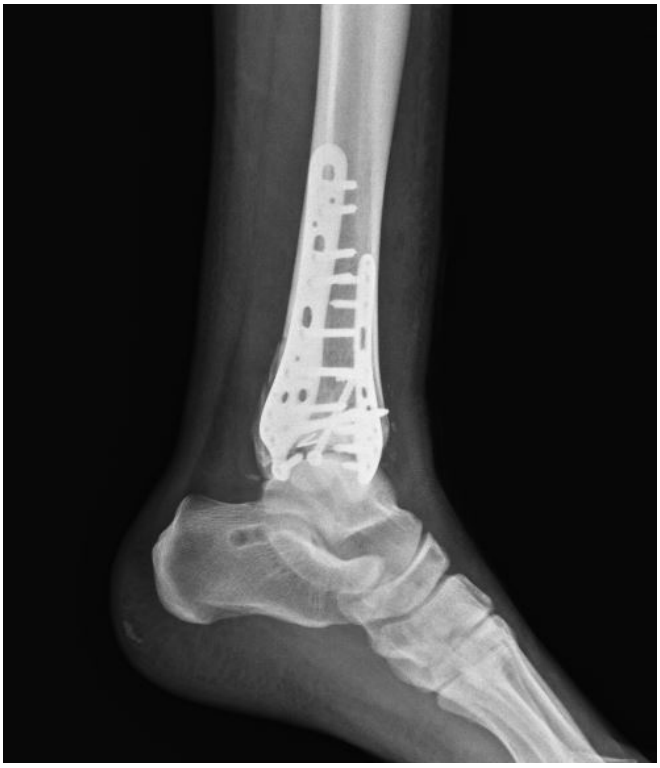

Figure 5. Post-operative lateral X-ray of the ankle.

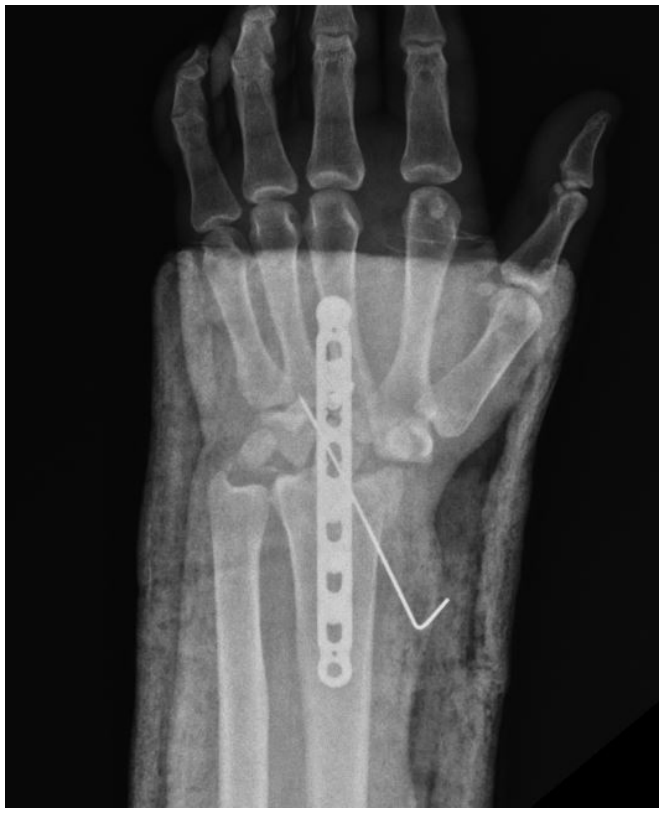

Figure 6. Post-operative anteroposterior X-ray of the wrist following wrist arthrodesis.

CONCLUSION

The treatment of distal tibial OCLs is surgically challenging, particularly when accompanied by metaphyseal bone loss and comminuted articular surface damage. In this case report, the successful use of autologous cartilage graft harvested from proximal carpal bones was demonstrated in the rare context of simultaneous wrist arthrodesis and ankle osteochondral defect. In appropriately selected cases, autologous cartilage obtained from different anatomical regions may offer an effective and alternative option for joint surface reconstruction. Long-term follow-up results were functionally satisfactory, and this method is presented as a novel approach with potential to contribute to the current literature.

DECLARATIONS

Ethics Committee Approval: This is a single case report, and therefore ethics committee approval was not required in accordance with institutional policies.

Informed Consent: Written informed consent was obtained from the patient for the scientific use of their data presented in this study.

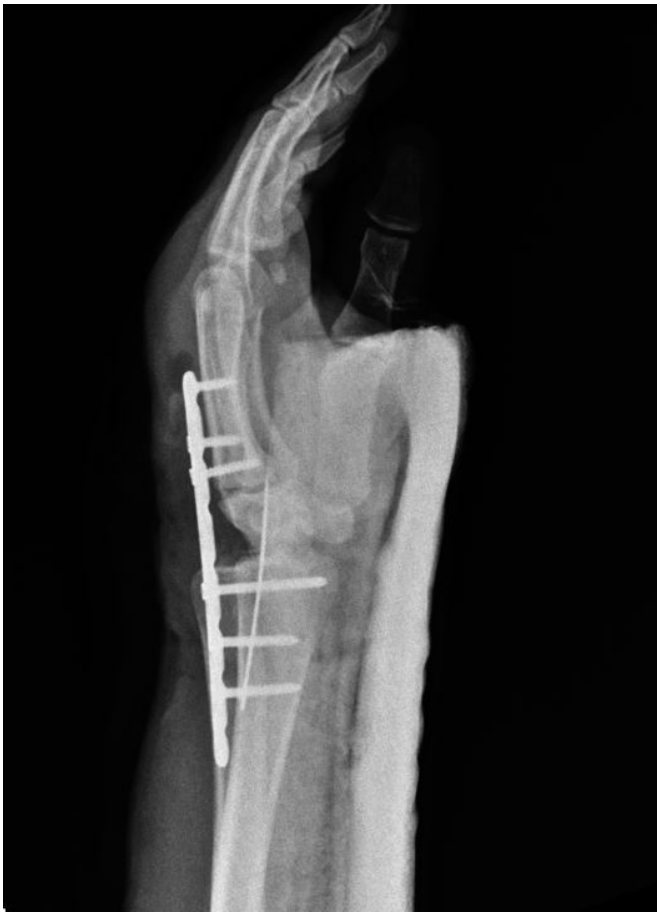

Figure 7. Post-operative lateral X-ray of the wrist following wrist arthrodesis.

Conflict of Interest: The authors declare that there is no conflict of interest.

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Authorship Contributions: Concept – EI; Design – BB; Supervision – EI; Fundings – BB; Materials – BB; Data collection &/or processing – BB; Analysis and/or interpretation – EI; Literature search – EI; Writing – EI; Critical review – EI.

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LETTER TO THE EDITOR

European Archives of Medical Research

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Eur Arch Med Res 2025;41(2):122–123

Letter to Editor for the Assessment of Bronchiolitis Severity Using Modified Tal and BROSJOD Scores

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Cite this article as: Yalımol M. Letter to Editor for the Assessment of Bronchiolitis Severity Using Modified Tal and BROSJOD Scores. Eur Arch Med Res 2025;41(2):122–123.

Dear Editor,

I have thoroughly reviewed the article titled "Assessment of Bronchiolitis Severity Using Modified Tal and BROSJOD Scores" by Leyla Alibayli and colleagues, published in European Archives of Medical Research (2025;41(1):24–31). This study evaluates the prognostic value of Modified Tal (M-Tal) and Bronchiolitis Score Sant Joan de Deu (BROSJOD) scores in infants with acute bronchiolitis. Below, I present the strengths, limitations, and recommendations for the manuscript.

STRENGTHS OF THE ARTICLE

Clinical Applicability

The study clearly demonstrates the association of M-Tal and BROSJOD scores with high-flow nasal cannula (HFNC) requirement and hospital stay duration in a prospective cohort. Notably, the significantly higher HFNC need in patients with M-Tal >7.5 and BROSJOD >10 (p=0.001) highlights their potential utility in clinical decision-making.[1]

Methodological Rigor

Exclusion of confounders such as age, comorbidities, and prematurity strengthens internal validity. Inclusion of COVID-19-positive patients also adds pandemic-specific data diversity.[1]

POTENTIAL LIMITATIONS AND RECOMMENDATIONS

Sample Size

The single-center design with 111 patients limits statistical power, particularly in the subgroup requiring HFNC (n=22). Multicenter studies with larger cohorts would improve generalizability. Similar limitations were noted in a study differentiating testicular torsion from epididymo-orchitis using inflammatory markers.[2]

Lack of Blood Gas Parameters

Blood gas analyses were only performed at admission, with no follow-up data. McCallum et al.[3] emphasized that late-term blood gas changes could correlate with dynamic score values. This gap was also observed in a Stanford Type B aortic dissection study.[4]

Comparison with Other Scores

The absence of comparisons with tools such as the Modified Wood's Clinical Asthma Score (M-WCAS) is notable. Golan-Tripto et al.[5] demonstrated concordance between M-Tal and M-WCAS.

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RECOMMENDATIONS FOR FUTURE STUDIES

Randomized Controlled Trials

Investigate the impact of initiating HFNC based on these scores. Innovative indices, such as the pan-immune inflammation value used to predict strangulation in incarcerated hernias, could be tested in similar contexts.[2,6]

Biomarker Integration

Combining scores with biomarkers such as procalcitonin may enhance prognostic accuracy. The success of NLR and SII in predicting mortality in acute cholecystitis supports this approach.[7]

CONCLUSION

This study supports the clinical utility of M-Tal and BROSJOD scores in assessing bronchiolitis severity. However, limitations such as sample size and longitudinal data gaps warrant future research. As seen in studies on complicated appendicitis,[8] multidisciplinary integration of inflammatory indices could enrich the body of knowledge in this field.

DECLARATIONS

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