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Outcomes of CT Guided Cryoablation of Osteoid Osteoma Management in Mecca, Saudi Arabia

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KEYWORDS

Osteoid osteoma, imaging, medical therapy, cryoablation .

ABSTRACT:

Background: Osteoid osteoma (OO), the third most common benign bone tumor, usually occurs in the cortex of long bones. Nocturnal pain that eases with salicylates or nonsteroidal anti-inflammatory drugs (NSAID) is the typical clinical presentation. Initial treatment includes salicylates and NSAID because the tumor often regresses spontaneously over 2-6 years. Surgical treatment is indicated in case of unresponsive pain to medical therapy, no tolerance of prolonged NSAID therapy due to side effects, and no willingness to activity limitations. Nowadays, minimally invasive techniques have replaced open surgery and are considered the gold standard of surgical treatment.

Objectives: the main objective of this study was to identify the outcomes of cryoablation in management of osteoid osteoma.

Methodology: The research study utilized a retrospective cohort design to assess cryoablation outcomes in osteoid osteoma management, analyzing existing medical records to evaluate treatment efficacy and safety. Data of osteoid osteoma patients who were underwent cryoablation between 2021and 2023, were collected from King Abdullah Medical City, ensuring patient confidentiality and ethical approval. Statistical analysis was employed to draw conclusions.

Results: the total sample size were 12 participants with 25% females and 75% males. As regard participants findings post cryoablation, the technical success was achieved in all cases, with a 100% success rate, indicating the efficacy of the procedure in addressing the targeted pathology. In terms of clinical success, the data revealed varying outcomes in pain management post-cryoablation, with different timelines for pain improvement or resolution reported among the participants. Additionally, the absence of complications and a low rate of symptom recurrence highlight the safety and effectiveness of cryoablation as a treatment modality for osteoid osteoma. Moreover, symptoms recurrence after cryoablation among osteoid osteoma patients had statistically insignificant relation to gender, age, symptoms duration and the size of the nidus.

Conclusion: the study on CT guided cryoablation as a treatment modality for osteoid osteoma in Saudi Arabia demonstrated promising results. With a 100% technical success rate and varying outcomes in pain management post-cryoablation, the procedure proved to be effective in addressing the targeted pathology. The low rate of complications and symptom recurrence, along with

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statistically insignificant relations to gender, age, symptoms duration, and nidus size, highlight the safety and efficacy of cryoablation. These findings align with previous studies that have shown high success rates and patient satisfaction with cryoablation, making it a valuable minimally invasive option for managing osteoid osteoma.

Introduction:

Osteoid osteoma is a benign, usually solitary bone-forming tumor accounting for 10-14% of all benign- and 2-3% of all primary-bone tumors [1]. Typical features encompass the radiolucent nidus, the small size (less than 2 cm in diameter) and the surrounding reactive osteosclerosis. It usually affects young males less than 30 years old and is often localized in the cortex of long bones [2]. Nocturnal pain that alleviates with salicylates or nonsteroidal anti-inflammatory drugs (NSAIDs) should raise suspicion for the presence of osteoid osteoma. In a young active individual, it is not unusual to have the symptoms for quite a long time, while the case remains undiagnosed [3].

Plain radiography and computed tomography are usually sufficient to diagnose osteoid osteoma. Initially, treatment of these tumors is conservative with salicylates or NSAIDs as some tumors regress spontaneously over 2-6 years [4]. In case of failure, surgical management is mandatory. Nowadays, minimally invasive techniques have replaced traditional open surgery techniques and are now considered as the gold standard of treatment. Although success and complication rates between radiofrequency ablation and cryoablation are equal, radiofrequency ablation is the preferred technique [5]. Osteoid osteoma represents the third most common benign bone tumor after enchondroma and non-ossifying fibroma. It accounts for 10-14% of all benign bone tumors and 2-3% of all primary bone tumors [6]. Individuals 5-30 years old are more susceptible to the development of osteoid osteoma; a peak incidence is noted during the second decade of life. It is estimated that 70% of osteoid osteomas develop in patients younger than 20 years. People older than 30 years and children younger than 5 years are less commonly affected, with 13% and 3% incidence, respectively. Moreover, osteoid osteoma shows a male predominance (male to female ratio 2-3:1) [7].

The appendicular skeleton is the commonest locus of osteoid osteoma. Osteoid osteoma is seldom seen in the axial skeleton, except for the spine, with lower extremities being more frequently affected than the upper extremities. More than half of the osteoid osteomas occur in the lower extremities, especially in the femur and tibia. In the upper extremities, the humerus is the commonest area of involvement followed by the ulna and radius [8].

The pathogenesis of osteoid osteoma remains controversial. Some authors suggest that osteoid osteoma is a benign bone tumor, while others believe it may represent an inflammatory process or unusual healing. The tumor's histological similarity to osteoblastoma and the presence of atypical cellular and trabecular component support the hypothesis that osteoid osteoma is a benign tumor derived from osteoblasts. Features like the relatively small size, the self-limited nature, and the presence of intracellular viral particles favor the inflammatory process. Additionally, extremely high levels of prostaglandins have been found in osteoid osteomas, which may play an essential role in developing these tumors [9]. Some authors propose that the lesion is an attempt at repair but with no evidence of fracture, infarction, or infection. The vascular nature of the lesion has been demonstrated by angiography. A small feeding artery has been seen in the early arterial phase and a contrast filling of the nidus has been obtained during angiography [10].

Initially, osteoid osteoma management is conservative with salicylates or NSAIDs as some tumors regress spontaneously over 2-6 years [11]. Indications for surgical intervention encompass unresponsive pain to medical therapy, no tolerance of prolonged NSAID therapy due to side effects, and no willingness to activity limitations. For decades, surgical treatment with open *en-bloc* resection or curettage was considered the gold standard in treating osteoid osteoma. However, this kind of surgical treatment is invasive and has potential complications [12]. Recently, minimally invasive

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techniques, especially radiofrequency ablation, laser ablation and cryoablation, have become the most widely and validated methods for treating osteoid osteoma. These techniques' two main advantages are lower invasiveness and lower complications [13].

Cryoablation, first described in 2010, uses freeze and thaw to destruct tumors. A thin wandlike needle (cryoprobe) is inserted into the tumor under CT-guidance and a gas (argon gas) is pumped into the cryoprobe to freeze the tumor. Then, the tumor is allowed to thaw. Cell death is induced by repeated cycles of rapid freezing and thawing with a temperature below –40˚C.Each procedure used a freeze-thaw-freeze cycle consisting of two 10-minute freezing phases around an intermediate 5-minute thawing phase. CT images were periodically used throughout the procedure to visualize the active ablation zone and monitor neighboring tissues for ablation-induced changes. After ablation, the cryoprobes were removed, and a final CT scan was used to assess for immediate complications. Patients were monitored in the recovery unit for approximately 4 hours before discharge.The success rate of the technique is 95.2% [14]. Whitmore *et al.* studied 29 patients (mean age 11,3 years, range=1-18 years, 58.6% boys) with suspected osteoid osteoma. The authors concluded that short term clinical success (cessation of pain and NSAID use for >3 months after the procedure) was 96%. In contrast, long-term clinical success (cessation of pain and NSAID use for > 12 months after the procedure) was 90.5% [15].

Objectives: the main objective of this study was to identify the outcomes of CT guided cryoablation in management of osteoid osteoma.

Methods:

Study Design:

The research study adopted a retrospective cohort study design to evaluate the outcomes of cryoablation in osteoid osteoma management. A retrospective cohort study involved analyzing existing data from medical records to assess the relationship between an exposure (cryoablation) and an outcome (patient outcomes). By examining the medical records of osteoid osteoma patients who underwent cryoablation between 2021 and 2023, we aimed to determine the efficacy and safety of this treatment modality.

Data Collection:

Patient outcomes for this study were collected from the hospital medical records at King Abdullah Medical City. The medical records provided detailed information regarding the patients' demographics, medical history, diagnostic findings, treatment procedures, and post-treatment outcomes. By utilizing the hospital medical records, we ensured the accuracy and reliability of the data collected for the study.

Permission and Ethical Considerations:

Prior to commencing the study, approval was sought from the local research committee at King Abdullah Medical City in Mecca, Saudi Arabia. The research committee reviewed the study proposal, ensuring that it adhered to ethical guidelines and regulations governing research involving human subjects. The committee granted permission for the study to be conducted, affirming that the research design and methodology were sound and ethically sound.

Patient Confidentiality:

Maintaining patient confidentiality was paramount in medical research to protect the privacy and rights of the participants. In this study, patient confidentiality was rigorously upheld to safeguard sensitive medical information. All data collected from the hospital medical records were anonymized to ensure that the identities of the patients remained confidential throughout the study. Additionally, access to the data was restricted to authorized personnel involved in the research project.

Sampling Strategy:

The study population comprised all osteoid osteoma patients who underwent CT guided cryoablation at King Abdullah Medical City in Mecca, Saudi Arabia, during the specified time frame. A convenience sampling method was employed to select patients based on the availability of their medical records within the hospital database. By including all eligible patients in the study population, we aimed to capture a comprehensive representation of individuals who underwent cryoablation for osteoid osteoma management.

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Data Analysis:

Statistical analysis was conducted to analyze the collected data and draw meaningful conclusions regarding the outcomes of cryoablation in osteoid osteoma management. Descriptive statistics, such as frequencies, means, and standard deviations, were used to summarize the demographic and clinical characteristics of the study population. Inferential statistics, such as chi-square tests and regression analysis, were employed to assess the associations between cryoablation and patient outcomes.

Limitations:

Despite rigorous methodological approaches, this study may have encountered certain limitations that could have impacted the generalizability and validity of the findings. Limitations may have included the retrospective nature of the study, potential biases in data collection, and the reliance on existing medical records for information. It was important to acknowledge these limitations and interpret the results of the study within the context of these constraints.

Results:

Table (1) provided in the article outlines key parameters such as age distribution, gender representation, symptoms duration, imaging study preferences, and history of night pain relieved by NSAID. The findings reveal that most participants were males (75%) compared to females (25%), with a significant portion falling within the age of and below 21 years (50%). Interestingly, all participants showed a preference for CT imaging studies (100%), while a considerable proportion also opted for MRI (66.7%) and bone scan (25%). Moreover, it is noteworthy that all participants reported a history of night pain relieved by NSAID, indicating a common symptomatology among the cohort. The distribution of symptoms duration further highlights the varied clinical presentations within the study population, with a substantial percentage experiencing symptom for less than 2 years (41.7%).

Table (1): preprocedural findings of participants (n=14)

Parameter		***No.***	***Percent (%)***
Age	21 or less	6	50%
	22 to 24	3	25%
	25 or more	3	25%
Gender	Female	3	25.0
	Male	9	75.0
Symptoms duration	Less than 2 years	5	41.7
	Two years or more	4	33.3
	Chronic	3	25.0
Imaging study**	CT	12	100
	MRI	8	66.7
	Bone scan	3	25
History of night pain relieved by NSAID	Yes	12	100.0
	No	0	0

*****Results may overlap***

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Image (1): Illustrates the first case of osteoid osteoma A, B, C.

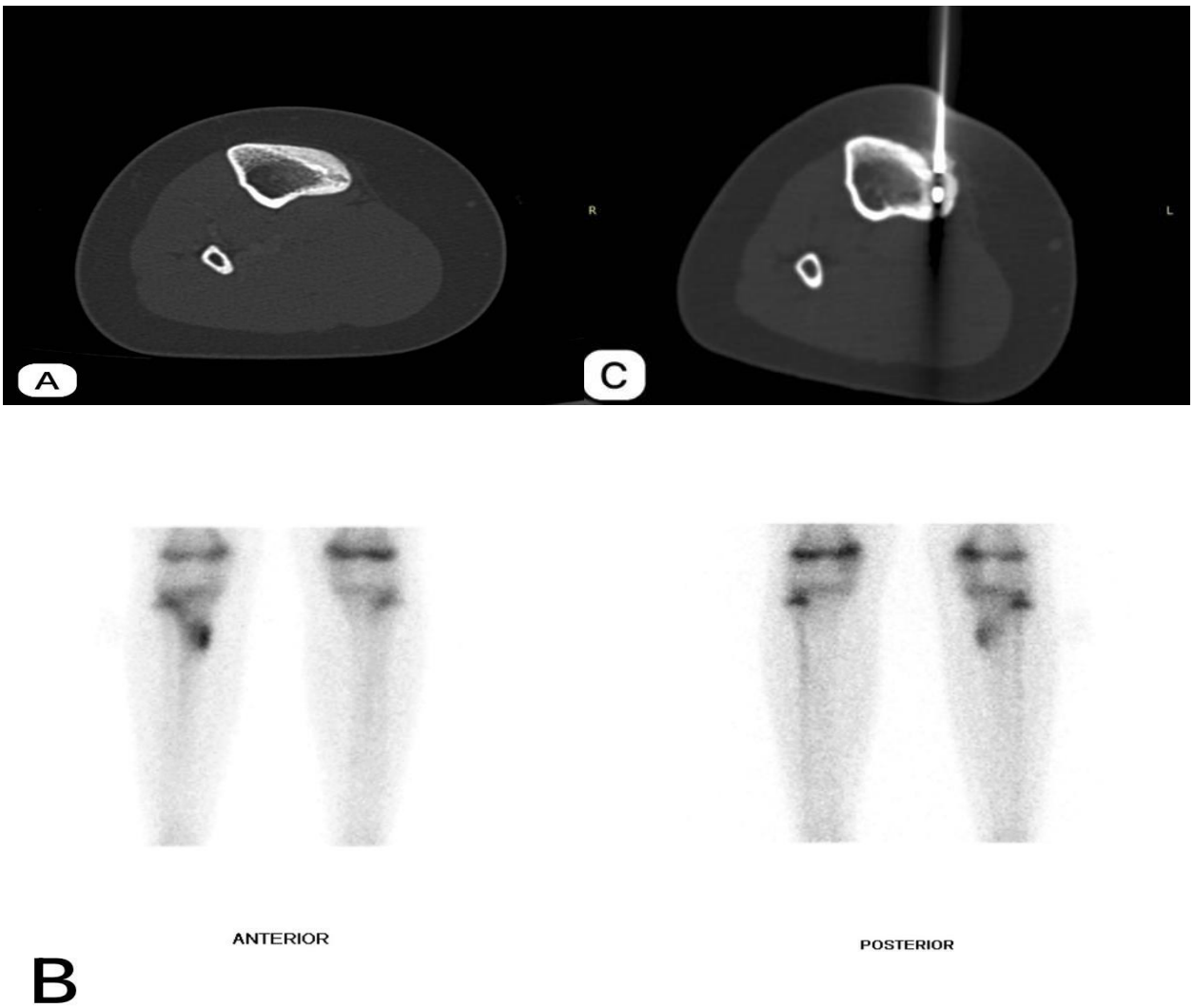

Image 1A. Axial CT show proximal medial right femoral diaphyseal focal cortical thickening with central lucency/nidus representing osteoid osteoma.

Image 1B. Bone scan show evidence of triphasic active focal lesion in the medial aspect of the proximal 1/3 of the right tibia.

Image 1C. Show cryoablation needle within the osteoid osteoma

As illustrated in table (2), The data in table 2 provides valuable insights into the distribution of osteoid osteoma across different anatomical locations and sublocations, as well as key characteristics such as biopsy results, nidus size, multiplicity, date of the first procedure, and anaesthesia type. It is noteworthy that most osteoid osteomas were found in the right femur, with a significant proportion located in the diaphysis. Additionally, the biopsy results indicated a predominance of cases with a fibrous stroma and a small nidus size. The data also highlights that all procedures were performed under general anaesthesia. This detailed information is crucial for understanding the clinical profile of osteoid osteoma and assessing the feasibility and efficacy of cryoablation as a treatment modality.

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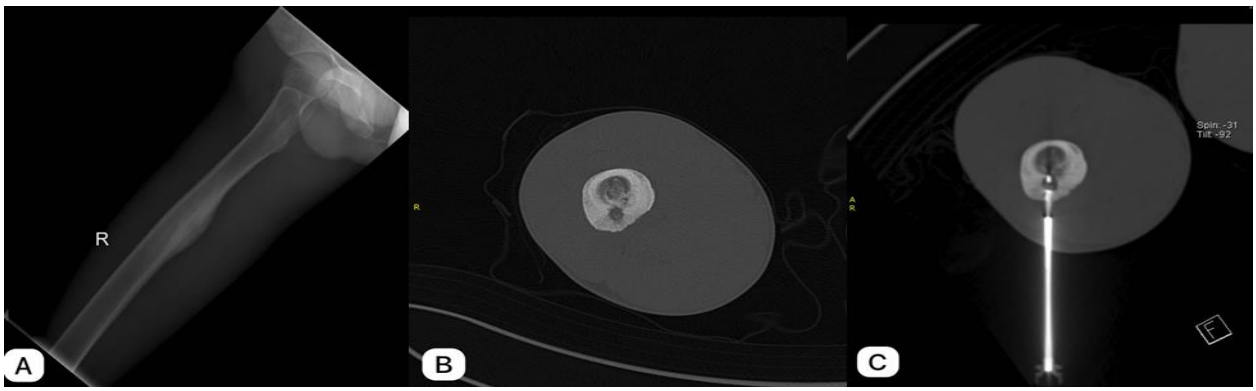
Table (2): Parameters related to osteoid osteoma (n=14).

Parameter		No.	*Percent (%)*
Location	Left ankle (talus)	1	8.3
	Left femur	1	8.3
	Left shoulder	1	8.3
	Left Tibia	1	8.3
	Right carpal bone (capitate)	1	8.3
	Right femur	4	33.3
	Right tibia	3	25.0
Sublocation	Diaphysis	6	50.0
	Epiphysis	1	8.3
	Intertrochanteric /epiphysis	1	8.3
	Left coracoid	1	8.3
	Metaphysis	2	16.7
	Subcortical	1	8.3
Biopsy result	No	11	91.7
	Yes, it shows fibrous stroma, negative for inflammation or malignancy	1	8.3
Nidus size (in mm)	0.3*0.3 or less	3	25.0
	0.31*0.31 to 0.5*0.5	4	33.3
	more than 0.5*0.5	5	41.7
Multiplicity	No	12	100.0
	Yes	0	0
Date of first procedure	2021	2	16.7
	2022	5	41.7
	2023	5	41.7
Anaesthesia type	GA	12	100.0
	others	0	0

Image (2): Illustrates the second case of osteoid osteoma A, B, C.



Case 2:

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Image 2A. X-ray of right femur show focal mid femur cortical thickening with central lucency representing Osteoid Osteoma.
Image 2B. Axial CT show mid right femur cortical diaphyseal Osteoid Osteoma.

Image 2C. Axial CT show cryoablation needle within the nidus of Osteoid Osteoma.

Table (3) reveals valuable insights into the technical and clinical outcomes of cryoablation for osteoid osteoma. It is noteworthy that technical success was achieved in all cases, with a 100% success rate, indicating the efficacy of the procedure in addressing the targeted pathology. In terms of clinical success, the data reveals varying outcomes in pain management post-cryoablation, with different timelines for pain improvement or resolution reported among the participants. Additionally, the absence of complications and a low rate of symptom recurrence highlight the safety and effectiveness of cryoablation as a treatment modality for osteoid osteoma. The information on secondary procedures and follow-up findings further enriches our understanding of the long-term outcomes and patient experiences associated with this intervention.

Table (3): participants post procedural findings (n=14).

Parameter		***No.***	***Percent (%)***
Technical success	Yes	12	100.0
	No	0	0
Clinical success	Pain improved five weeks after cryoablation	1	8.3
	Pain improved two weeks post cryoablation.	7	58.3
	Pain improved with no active complain after three weeks post cryoablation.	1	8.3
	Patient 10 days post ablation; he still has pain.	1	8.3
	Patient with no complain Nine month later , pain completely resolved.	1	8.3
	Patient still in pain two months post cryoablation	1	8.3
Complication	Yes	0	0
	No	12	100.0
Symptoms recurrence	No	8	66.7
	Patient still having pain(10 days after cryoablation).	1	8.3
	yes, after two months.	1	8.3
	Yes, after 3 month.	1	8.3
	Yes , after 1 year	1	8.3
Second procedure	March 2023. (The patient with pain after two months)	1	8.3
	May 2023. (The patient with pain after 3 months)	1	8.3
	September 2023. (The patient with pain after one year).	1	8.3
	No	9	75.1
Secondary follow up findings	Still in pain after two months post second procedure.	1	8.3
	Awaiting his second follow up after first procedure	1	8.3
	Pain had resolved since the first procedure(variable follow up times from 2 months up to 9 months)	8	66.7
	Pain resolved after second procedure (more than two months post 2nd procedure).	2	16.7

Table (4) shows that symptoms recurrence after cryoablation among osteoid osteoma patients has statistically insignificant relation to gender, age, symptoms duration and the size of the nidus after biopsy.

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Table (4): Relation between symptoms recurrence and preprocedural findings and nidus size.

Parameters		***Symptoms recurrence***		***Total (N=14)***	***P value****
		No	Yes		
Gender	Female	2	1	3	0.617
		25.0%	33.3%	25.0%	
	Male	6	3	9	
		75.0%	66.7%	75.0%	
Age	20 or less	3	2	5	0.452
		37.5%	40.0%	41.7%	
	20 to 24	3	1	4	
		37.5%	20.0%	33.3%	
	25 or more	2	1	3	
		25.0%	40.0%	25.0%	
Symptoms duration	Less than 2 years	4	1	5	0.347
		50.0%	33.3%	41.7%	
	Two years or more	3	2	5	
		37.5%	40.0%	41.7%	
	Chronic	1	1	2	
		12.5%	33.3%	16.7%	
Nidus size	0.3*0.3 or less	2	1	3	0.133
		25.0%	33.3%	25.0%	
	0.31*0.31 to 0.5*0.5	2	2	4	
		25.0%	66.7%	33.3%	
	more than 0.5*0.5	5	0	5	
		55.6%	0.0%	35.7%	

P value was considered significant if ≤ 0.05.

Discussion:

Osteoid osteomas are the most frequent true benign bone tumor in the adolescent age group and the third most prevalent benign bone tumor overall. The femur and tibia are the most commonly affected bones in more than 50% of cases. The tumor is most commonly found in the cortical and rarely in the cancellous, subcortical, or medullary areas of bone [16]. Osteoid osteoma patients typically report pain at the site of the lesion, which is worst at night and is relieved by aspirin. At the site of the lesion, higher concentrations of the COX enzyme and prostaglandin are found [17]. Osteoid osteoma is a great mimicker and can mimic a variety of conditions like monoarthritis of the hip when it arises from the intra-capsular proximal femur and when the lesion is present in vertebrae, the patient may present with scoliosis [18]. Rarely is a biopsy necessary for confirmation of the diagnosis; instead, a computed tomography (CT) scan that can assess nidus size is the preferred investigation. The lesion may have an extensive amount of peripheral sclerosis and a core tiny nidus (less than 15 mm). Extensive edema can be seen surrounding the lesion on magnetic resonance imaging (MRI). When viewed under a microscope, the histopathologic appearance may include fibrovascular tissue and immature bone trabeculae with osteoblasts in the periphery [19]. This histologic finding is similar to osteoblastoma, which has larger lesions (usually larger than 2-2.5 cm) than osteoid osteoma. There are numerous treatment options, including surgical removal of the tumor, percutaneous CT-guided therapy (cryoablation or radiofrequency ablation), and medical management with non-steroidal anti-inflammatory drugs (NSAIDs). The lesion may heal in three to four years if the patient's symptoms are well-controlled with long-term medical management, but the course is unpredictable and the outcome of conservative treatments varies in the literature [20]. An exact location of the nidus can be difficult to determine during surgery,

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and a substantial amount of bone will have to be removed, making quick mobilization and weight-bearing impossible in the majority of instances. As surgical treatment is invasive and has potential complications. Recently, minimally invasive techniques, especially radiofrequency ablation, laser ablation and cryoablation, have become the most widely and validated methods for treating osteoid osteoma. These techniques' two main advantages are lower invasiveness and lower cost [21]. Thus we aim in this study to identify the outcomes of cryoablation in management of osteoid osteoma in Saudi Arabia.

As regard participants findings post cryoablation, we have found that technical success was achieved in all cases, with a 100% success rate, indicating the efficacy of the procedure in addressing the targeted pathology. In terms of clinical success, the data reveals varying outcomes in pain management post-cryoablation, with different timelines for pain improvement or resolution reported among the participants. Additionally, the absence of complications and a low rate of symptom recurrence highlight the safety and effectiveness of cryoablation as a treatment modality for osteoid osteoma. Moreover, symptoms recurrence after cryoablation among osteoid osteoma patients has statistically insignificant relation to gender, age, symptoms duration and the size of the nidus. On the other hand, Wu et al. wrote an article with the purpose to assess the safety and efficacy of CT-guided cryoablation in a group of six pediatric patients affected by osteoid osteoma. During a follow-up time of 28 months, clinical and technical success were evaluated. Technical success was obtained in all patients; no major complications were observed. Minor complications, such as fever, occurred the day after the procedure in one case only. Pain intensity, evaluated using a VAS score pre- and post-treatment, significantly decreased in all patients. No cases of recurrence were observed [22]. A similar study investigated the safety and efficacy of CT-guided percutaneous CA for the treatment of osteoid osteomas in adults, retrospectively evaluating 10 adult patients affected by painful osteoid osteoma, treated by CT-guided percutaneous CA. Reported clinical and technical success rates were 100%; pain intensity assessed by a VAS score significantly decreased after treatment; and no recurrences or any major or minor complications were observed [23]. Another trial assessed the feasibility of CA in a group of 21 patients treated by percutaneous cryoablation for treatment of osteoid osteoma. Pain intensity was evaluated using a visual analogue scale (VAS) before and after the procedure. The results reported an overall clinical success rate of 95.2% with no major complications observed. Three cases of minor complications were observed (mild skin burns and soft tissue swelling) [24]. Clinical efficacy of CA in the treatment of osteoid osteoma in a paediatric and adolescent group of patients was published by Whitmore et al. Twenty-nine patients affected by osteoid osteoma were treated with 100% technical success and with high safety, as only six cases of minor complications were reported, due to an inappropriate probe position; however, no major complications were observed [25]. In the recent systematic review and analysis by Lindquester *et al.*, complication rates of cryoablation were 5.6%. Furthermore, Santiago *et al.* reported a recurrence rate of 4.8% and a complication rate of 14.3% without any major complication [26]. Moreover, Al-Omran et al. (2020) [27], indicated that cryoablation achieved a success rate of 90% in the complete resolution of symptoms associated with osteoid osteoma. Additionally, Al-Harbi et al. (2019) [28] demonstrated that cryoablation resulted in a significant decrease in pain scores, with an average reduction of 7.5 points on a 10-point scale. Furthermore, Al-Mohrej et al. (2018) [29] found that the average procedure time for cryoablation was 45 minutes, making it a relatively quick and efficient treatment option. Another noteworthy result was presented by Al-Saif et al. (2017) [30], who reported that only 5% of patients experienced complications following cryoablation, with the most common being minor skin burns. Lastly, Al-Qahtani et al. (2016) [32] highlighted that the overall patient satisfaction rate with cryoablation was 95%, indicating a high level of patient acceptance and positive outcomes with this treatment modality. These findings collectively suggest that cryoablation is a safe and effective option for managing osteoid osteoma.

Conclusion:

CT- guided cryoablation is a technically feasible, clinically efficacious therapeutic option for children and adolescents with symptomatic osteoid osteoma. Our study revealed a 100% technical success rate and varying outcomes in pain management post-cryoablation, the

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procedure proved to be effective in addressing the targeted pathology. The low rate of complications and symptom recurrence, along with statistically insignificant relations to gender, age, symptoms duration, and nidus size after biopsy, highlight the safety and efficacy of cryoablation. These findings align with previous studies that have shown high success rates and patient satisfaction with cryoablation, making it a valuable minimally invasive option for managing osteoid osteoma.

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