Article published online: 2024-07-22

Original Article

Clinical and Radiologic Outcomes after Cryoablation of Desmoid Tumors

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J Clin Interv Radiol ISVIR

Abstract

Purpose This study aims to evaluate the impact of cryoablation on patients with desmoid tumors, considering both pain and functional impairment. Cryoablation has emerged as a promising intervention, primarily recognized for its ability to reduce radiological evidence of the neoplasm. However, the focus of this research is on assessing the clinical outcomes, recognizing the importance of improving patient-reported symptoms as additional evidence is required in this area to strengthen previous findings.

Methods A retrospective study of 18 patients treated with cryoablation for desmoid tumors were included in this study. The evaluation of clinical status involved structured interviews to capture changes in pain and functional impairment. Pain scores and functional impairment scores were recorded on a 10-point Likert scale before and after the treatment. The correlation between these clinical findings and imaging was a key aspect of the investigation.

Results Following cryoablation treatment, the average pain scores exhibited a notable decrease of 4.75 points on the 10-point Likert scale. Similarly, functional impairment scores demonstrated a significant average decrease of 4.0 points. Additionally, there was an overall decrease in viable tumor volume after ablation, correlating with the above findings.

Conclusion This study provides evidence that cryoablation is effective in achieving clinically significant improvement in patients with desmoid tumors. While the reduction in radiological evidence is recognized, the emphasis of this study was on patient-reported outcomes, particularly in pain and functional impairment. These findings underscore that cryoablation is a valuable intervention in the comprehensive management of desmoid tumors improving overall quality of life.

Keywords
- desmoid tumors
- cryoablation

Introduction

Desmoid tumors are a rare mesenchymal neoplasm that are locally invasive, but do not metastasize.[1] Despite being considered a benign entity, they often cause significant morbidity and mortality due to their rapid growth and exertion of local mass effect. This can result in substantial pain in the adjacent soft tissues, joints, or other nearby structures. Life-threatening complications from these tumors are a consequence of compression on vital structures such as within the abdominal cavity.[2] While desmoid tumors are a rare entity and account for only 0.03% of all neoplasms

DOI https://doi.org/10.1055/s-0044-1788253.
ISSN 2457-0214.

Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

and effect two-to-four people per million, they have a significant impact on quality of life and daily function.[3–7]

Management of desmoid tumors is a challenge due to their aggressive nature and high rates of recurrence. The primary goal of management is improvement in patient symptoms and function, while curative intent is often secondary. Surgical resection is considered a first-line therapy, but is associated with high morbidity and high recurrence rates.[8] Therefore, medical management is often considered. Chemotherapy with anthracycline containing regimens or vinca alkaloids with methotrexate have shown benefit, but are associated with systemic side effects.[9] Targeted therapy with imatinib and sorafenib and hormonal therapy with tamoxifen have shown some benefit, but also carry systemic side effects.[10] Nonsteroidal anti-inflammatory drugs have also been used, but with mixed results.[11]

Cryoablation has gained prominence in the management of desmoid tumors, exhibiting a reduction in radiological evidence of recurrence and minimal associated side effects.[12] Evidence also suggests that cryoablation leads to a decrease in symptoms and an improvement in quality of life.[4–7] In this study, the authors aimed to quantitatively assess posttreatment symptom and functional improvement, correlating these outcomes with radiologic findings in a heterogeneous group of patients. This endeavor seeks to provide further evidence regarding the generalizability of cryoablation in managing desmoid tumors across various anatomic locations. The authors hypothesized a clinically meaningful reduction in pain and a significant enhancement in day-to-day function, coupled with a decrease in viable tumor tissue following cryoablation compared with the pretreatment baseline.

Materials and Methods

Ethics approval was obtained from the Conjoint Health Research Ethics Board of the local institution. The study was performed in coordination with the ethics committee.

All patients who underwent image-guided cryoablation for the treatment of biopsy-proven desmoid tumors, regardless of anatomic site, at our institution from May 1, 2017 to May 1, 2022 were included in this study. Patients with desmoid tumors were excluded if they were asymptomatic or were less than 18 years old. All tumor volumes were increasing at the time of consultation with interventional radiology. Verbal and written consent for participation in this study were obtained.

A retrospective study was conducted with a predetermined study end date of May 1, 2022 regardless of whether the participant is scheduled for further interventions. Follow-up period ranged from 2 to 22 months after the last treatment. Patients were interviewed after the study end date and were presented a questionnaire to assess change in quality of life and daily pain along with procedural side effects and complications. This questionnaire involved standard questions such as, "Prior to the first cryoablation treatment, how would you rate your symptoms on a scale of 0 to 10? A 10 is the worst pain of your life and a 0 is no pain." Participants were then asked questions regarding their functional impairment and to quantify their functional impairment on a scale of 0 to 10 with a 10 constituting complete daily impairment and a 0 indicating no daily impairment. Symptoms were then quantified on a 10-point scale and symptom change was calculated by determining the difference between pre- and posttreatment scores. A score of 10/10 was to be considered as the worst pain the patient had ever experienced and 0/10 was no pain at all. Similarly, quality of life was quantified on a 10-point scale as described above and change in quality of life was determined by calculating the difference between pre- and posttreatment scores.

Magnetic resonance imaging (MRI) pretreatment and posttreatment were reviewed. MR studies were performed within a few days prior to the first treatment and was considered the baseline study. A MR study was performed at the conclusion of the study and was considered the posttreatment imaging. Patients underwent follow-up MRI 7 to 22 months after first treatment and 4 to 6 months after any repeat ablations. Initial viable tumor volume was measured by the authors by multiplying the coronal, sagittal, and transverse measurements using the TeraRecon software and subsequently similar measurements were performed on the follow-up study. Viable tumor volume was classified as such if the desmoid tumor tissue enhanced with intravenous contrast on T1 fat-suppressed images. Percentage of treated viable tumor was calculated based on pre- and posttreatment volume measurements following the modified Response Evaluation Criteria in Solid Tumors guidelines. Some representative cases of pretreatment MRI images, intraprocedural computed tomography (CT) guidance, and posttreatment MRI images are provided (►**Figs. 1**–**3**).

The cryoablation treatment was tailored for each patient based on the tumor size and location. Each procedure and MRI review were performed by the same interventional radiologist with 10 years of clinical experience. The analgesia and anesthesia protocol varied for each patient. Either general anesthesia or conscious sedation was used in combination with local anesthesia. When amenable, locoregional blocks were also performed for periprocedural and postprocedural pain management, including intercostal, peroneal, erector spinae, and transversus abdominis plane blocks, depending on tumor location. A range of Boston Scientific Visual Ice argon-based probes were inserted, either under ultrasound and/or CT guidance, in the tumor region, ranging from 4 to 15 probes in total. Needle sizes varied depending on the tumor size, morphology, and location. All probes were used simultaneously.

After the probes were inserted and confirmed in appropriate position, the ablation protocol consisted of a 10-minute freeze phase and a 5-minute passive thaw phase followed by an additional 10-minute freeze phase and a 5-minute active thaw

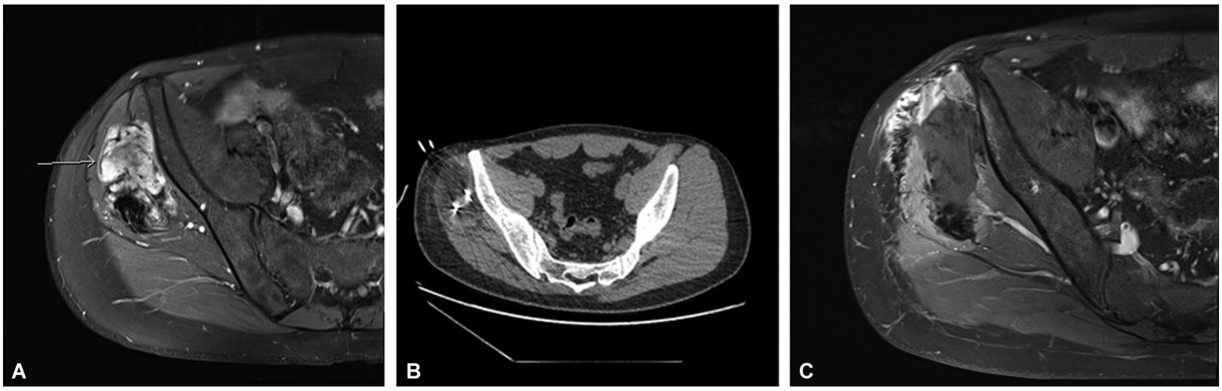

Fig. 1 Cryoablation treatment of a right gluteal desmoid tumor. Pretreatment (**A**) postgadolinium T1 fat-suppressed magnetic resonance imaging (MRI) image demonstrates a heterogeneously enhancing right gluteal desmoid tumor (arrow). Intraprocedural computed tomography (CT) image (**B**) demonstrates multiple probes in the region of the known desmoid tumor with a central hypoattenuating area in keeping with cryoablation treatment area. Posttreatment (**C**) postgadolinium T1 fat-suppressed MRI image demonstrates a decreasing volume of enhancing tumor with central necrotic components.

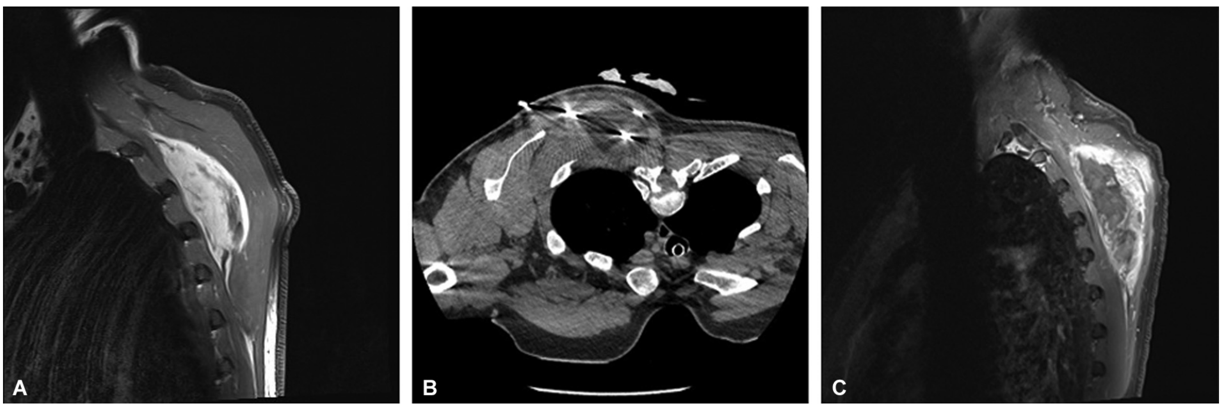

Fig. 2 Cryoablation treatment of a left posterior chest wall desmoid tumor. Pretreatment (**A**) postgadolinium T1 fat-suppressed magnetic resonance imaging (MRI) image demonstrates a heterogeneously enhancing left posterior chest wall desmoid tumor. Intraprocedural computed tomography (CT) image (**B**) demonstrates multiple probes in the region of the known desmoid tumor with a central hypoattenuating area in keeping with cryoablation treatment area. Posttreatment (**C**) postgadolinium T1 fat-suppressed MRI image demonstrates a decreasing volume of enhancing tumor with central necrotic components.

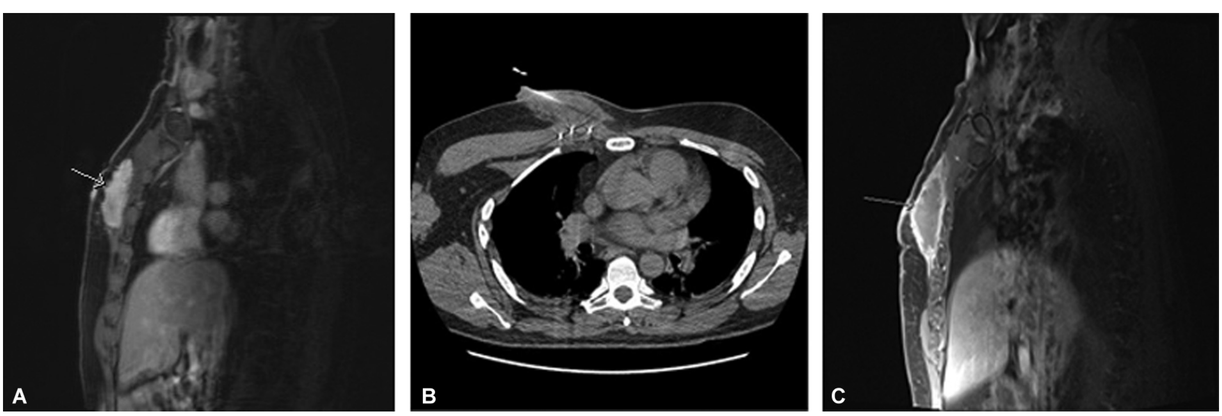

Fig. 3 Cryoablation treatment of a right anterior chest wall desmoid tumor. Pretreatment (**A**) postgadolinium T1 fat-suppressed magnetic resonance imaging (MRI) image demonstrates a heterogeneously enhancing right anterior chest wall desmoid tumor (arrow). Intraprocedural computed tomography (CT) image (**B**) demonstrates multiple probes in the region of the known desmoid tumor with a central hypoattenuating area in keeping with cryoablation treatment area. Posttreatment (**C**) postgadolinium T1 fat-suppressed MRI image demonstrates a decreasing volume of enhancing tumor with central necrotic components (arrow).

phase. This protocol was shortened if the frozen area was enlarging to the point where it could potentially harm adjacent vital organs such as the bowel or neurovascular bundles depending on tumor location. Intraprocedural dexamethasone was given to decrease inflammation and for postprocedural nausea. If a large area was treated or there was concern for compartment syndrome due to tumor location in an extremity, an additional course of steroids for 5 days was prescribed. Many precautions were taken to limit skin and nerve damage including surgical heat packs and hydrodissection to protect the nearby bowel or nerves. Nerve signal monitoring was performed in one case; however, biofeedback including monitoring intraprocedural motor and sensory function was the predominant method of monitoring nerve function.

Descriptive statistics, reported as median and range, are provided for pre- and posttreatment data.

Results

A total of 18 participants who underwent cryoablation for the treatment of a desmoid tumor were included in this study (►**Table 1**). Age of the participants ranged from 23 to 73 years with an average age of 40 years. Thirteen participants were females. Anatomic location of the desmoid tumors varied including involvement of either extremity, abdominal wall, pelvis, or neck. Five of the 18 participants did not have their tumor treated prior to cryoablation, while prior treatments in 13 patients primarily included tamoxifen, chemotherapy, or surgical resection. None of the patients were on treatment at the time of cryoablation. The average number of cryoablation treatments per participant was 2.3 with seven participants requiring between two and four additional procedures. Eleven of the 18 patients were treated with curative intent, the others were treated for palliation.

Table 1 Patient demographics

Characteristic	Number of participants ($n = 18$)
Average age	40 y (range = 23–73 y)
Sex	
Male	5 (28%)
Female	13 (72%)
Location of tumor	
Upper limb	1 (6%)
Lower limb	2 (11%)
Pelvis	6 (33%)
Chest wall	2 (11%)
Anterior Abdomen	3 (17%)
Lower back/flank	3 (17%)
Neck	1 (6%)
Prior therapy	
None	5 (28%)
Surgery only	1 (6%)
Surgery and medication	3 (17%)
SERMs only	4 (22%)
Chemotherapy	1 (6%)
NSAIDs	1 (6%)
Multiple medications	3 (17%)

Abbreviations: NSAIDs, nonsteroidal anti-inflammatory drugs; SERMs, selective estrogen receptor modulators.

Primary outcomes of this study included change in pain and daily function post-cryoablation. Based on the interview questionnaire the median pretreatment pain score was 5.75/10 (2–10) and the posttreatment pain score was 1/10 (0–5). This constituents a decrease in pain by 4.75 points on the 10-point pain scale (►**Table 2**). Furthermore, 12 of the 18 participants decreased use of analgesics post-cryoablation and 9 out of those 12 participants ceased analgesic use post-cryoablation. One participant increased their analgesic use after cryoablation.

Quality of life scores are reported in 13 out of 18 participants with median pretreatment functional impairment scores of 5/10 (3–10). After treatment median functional impairment scores were 1/10 (0–5) for an average decrease in functional impairment by 4.0 points (►**Table 2**). Furthermore, 16 out of the 18 participants had improvement in daily function after cryoablation and 2 out of the 18 participants had no change in daily function. None of the participants had an increase in functional impairment after cryoablation.

Mild adverse events as per the Society of Interventional Radiology occurred in three patients which included pain, blistering, and bruising at the site of treatment with up to a Grade 2 skin injury.[13] No skin grafts were required. Mild nerve injury occurred in 5 out of 18 participants including temporary or persisting regional numbness with one of those cases secondary to peroneal nerve injury, which was anticipated given the location of the tumor, also classified as mild adverse events. Symptoms related to the above adverse events resolved within weeks to 2 to 3 months after the procedure. There was an additional mild adverse event that involved trapezius muscle wasting due to spinal accessory nerve involvement at the treatment site. There was one case of a severe adverse event in which a patient developed rhabdomyolysis and required inpatient management and admission for 5 days. This was likely secondary to a large treatment area of a gluteal tumor and was managed conservatively with fluids. There was no significant associated renal dysfunction. In total, there were nine minor side effects and one major side effect.

Regarding MRI findings, in all but three cases there was a decrease in viable tumor volume after treatment with cryoablation. The median volume of viable tumor prior to treatment with cryoablation was 59 cm^3 (8.4–1006 cm^3). The median volume of viable tumor after treatment was 10 cm^3 (0–775 cm^3) (►**Table 3**). This indicates a decrease in viable tumor volume of 49 cm^3. In the 15 patients in whom there was a decrease in viable tumor the average percentage of treated viable tumor was 80%. In the three participants in whom there was an increase in viable tumor after treatment, the average percentage increase in viable tumor was 83%.

Table 2 Pretreatment and posttreatment clinical characteristics

Patient	Age	Sex	Pain score pretreatment	Pain score posttreatment	Functional impairment score pretreatment	Functional impairment score posttreatment	Adverse events
1	25	F	10	0	N/A	N/A	None
2	45	M	2	1	3	0.5	Blistering/bruising
3	27	M	4	1	6	1	None
4	29	F	6.5	0.5	N/A	N/A	None
5	61	F	9.5	1.5	N/A	N/A	None
6	29	M	8	1	N/A	N/A	Rhabdomyolysis
7	41	F	5	0	3	0	Blistering
8	39	F	8	1	N/A	N/A	None
9	45	F	8.5	1	6	1	Numbness
10	73	F	8	0	10	0	Blistering
11	39	M	8	3	5	3	Nerve injury
12	40	F	4	4	7	1	None
13	53	F	5	5	5	3	Trapezius wasting
14	43	F	5	3	6	3	Nerve pain
15	37	F	3	0	3	3	None
16	38	F	7.5	4.5	8	3.5	Jaw swelling
17	23	M	5	5	5	5	None
18	38	F	5	0	3	0	Numbness
Median			5.75	1	5	1	
Range			2–10	0–5	3–10	0–5	

Abbreviations: F, female; M, male; N/A, not available.

Discussion

Use of cryoablation has been shown to be effective at reducing the radiological evidence of viable desmoid tumors and for improving quality of life.[4–7] Therefore, the goal of this study was to corroborate those findings, particularly when treating desmoid tumors in different anatomic locations. Based on the results of this study, cryoablation does result in clinically significant improvement in both quality of life and pain reduction. Not only was there a subjective decrease in perceived pain after treatment, many patients reported an objective decrease in the use of analgesic medication. Considering two-thirds of the participants decreased their use of analgesia posttreatment, it is clear there was a clinically significant decrease in pain. Furthermore, approximately 89% of participants reported an improvement in daily function.

To further support the clinical benefit of cryoablation for the treatment of desmoid tumors it is vital that this therapy does not result in substantial adverse effects. While several patients experienced minor temporary side effects including blistering, bruising, and regional pain and numbness, only two participants experienced prolonged neuropathy which took a few months to improve. Intermediate to long-term adverse outcomes were more associated with the location of the desmoid tumor and involvement of associated nearby structures than a reflection of the cryoablation itself. Therefore, prior to performing cryoablation it remains essential to tailor the procedure including consent, approach, monitoring, and expected outcomes to each case.

In most participants, the improvement in clinical status correlates to a high percentage of treated viable tumor, further supporting the use of cryoablation for desmoid tumor for both clinical and radiological improvement. In the three cases in which there was an increase in viable tumor after treatment, two patients had improvement in pain scores and the other was stable. Two of these participants commented on their functional impairment and both demonstrated a reduction in such. This suggests that improvement in clinical status is not always dictated by radiological resolution of the desmoid tumor and that cryoablation can still provide clinical benefit, regardless of radiological change.

A recently published study by Yan et al also examined the use of cryoablation for the management of desmoid tumors.[12] The authors arrived at a similar conclusion, that cryoablation reduced total viable and whole tumor volumes with symptom relief and minimal adverse effects. While this study was robust, the authors did not focus on the clinical outcomes to the same extent as they focused on the imaging

Table 3 MRI characteristics

Patient	Viable tumor volume pretreatment (cm^3)	Residual viable tumor posttreatment (cm^3)	% of treated viable tumor
1	462	23	+95
2	52	0.3	+99
3	165	4	+98
4	88	3	+97
5	32	12	+63
6	66	96	–45
7	38	3	+92
8	18	0	+100
9	75	18	+76
10	8.4	0	+100
11	235	300	–28
12	1,006	775	+23
13	86	237	–176
14	338	223	+34
15	31	1	+97
16	8.5	1	+88
17	44	21	+52
18	43	8	+81
Median	59	10	
Range	8.4–1006	0–775	

Abbreviation: MRI, magnetic resonance imaging.
Note: Positive percentage represents a decrease in total viable tumor after cryoablation. Negative percentage represents an increase in total viable tumor after cryoablation.

changes. The current study aimed to further delineate clinical response to cryoablation to provide additional information that is essential when determining how desmoid tumors will be managed. The results of the study by Yan et al and of the current study suggest that the use of cryoablation in the management of desmoid tumors may result in improvement of clinical and radiological outcomes. The use of cryoablation in the management of desmoid tumors may be preferred to surgical resection after evaluation by a multidisciplinary team.

One limitation of this study is that the endpoint was predefined and many of the patients did have or are scheduled to have further cryoablation treatments. Therefore, it is possible that patient outcomes and adverse effects would change with further treatments. Another limitation is the inability to correctly identify radiological improvement and the true viable tumor component. Enhancing tumor was considered viable, however, it is occasionally difficult to differentiate nontreated viable tumor from scar/treatment response which often only becomes apparent on follow-up imaging studies. Moreover, while the tumor may recur, the clinical picture does not always match the radiological change and, therefore, it is essential to monitor the patient clinically to ensure adequate response to cryoablation and not to solely rely on MRI findings.

Conclusion

Cryoablation is an effective method for the management of desmoid tumors with clinically significant improvement in daily function and pain with associated improvement in imaging findings. This is in accordance with previously published literature and provides further evidence that this treatment is generalizable to many patients affected by this challenging to treat neoplasm regardless of anatomic location.

Ethical approval
Approval by Conjoint Health Research Ethics Board at the University of Calgary. Ethics ID: REB21–1623.

Funding
None.

Conflict of Interest
None declared.

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