

Anterior tibial artery preservation during limb salvage surgery: a novel technique with possible functional benefits

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SUMMARY

Background: Limb Salvage Surgery (LSS) for the proximal tibial tumours is technically challenging due to the complex surgical and vascular anatomy. Anterior Tibial Artery (ATA) is generally ligated to facilitate further dissection during surgery. We describe a technique of ATA preservation and its implications on functional outcomes.

Material and Methods: Retrospective study of patients undergoing LSS for proximal tibial osteosarcoma from December 2009 to January 2018 in a tertiary cancer center was done. Demographic profiles, tumor characteristics, operative details, functional outcomes and recurrence rates were analyzed.

Results: Twenty-two patients were included. The median age was 12.5 years. ATA preservation was performed in 13 patients. Functional outcomes using the MSTS score was higher at three, six and twelve months post-treatment in patients who had ATA preservation, although not statistically significant. Oncological outcomes were comparable.

Conclusion: ATA preservation is a feasible option in patients with upper tibial osteosarcomas undergoing LSS. A statistically non-significant benefit in functional outcomes was achieved with ATA preservation.

Key words: osteosarcoma, proximal tibia, anterior tibial artery preservation, limb salvage surgery

INTRODUCTION

The proximal tibia is the second most common site for osteosarcomas [1]. Cytotoxic chemotherapy and limb-salvage surgery remain the standard of care in management [2]. Limb Salvage Surgery (LSS) for proximal tibial tumours can be technically challenging owing to the complex vascular and surgical anatomy of the popliteal region. Anterior Tibial Artery (ATA) which courses along the interosseous membrane is usually ligated during resection of the upper end of the tibia for reducing blood loss and facilitating tumour extirpation [3]. However, preservation may be associated with better blood flow to the affected limb. This could enhance wound healing, facilitate early recovery and improve muscle tone (secondary to increased muscle blood flow and faster ambulation). Here we describe our experience of ATA preservation during LSS in patients with proximal tibial osteosarcomas and correlate with functional outcomes during follow up.

MATERIALS AND METHODS

This was a retrospective study of patients with osteosarcoma of the upper end of tibia undergoing surgery at our institute from June 2009 to January 2018. Patients with non-metastatic osteosarcoma of the proximal tibia were included in the study. Those with incomplete data were excluded. All underwent Magnetic Resonance Imaging (MRI) of the affected limb for local staging followed by core needle biopsy. Non-Contrast Enhanced Computerized Tomography (NCCT) scan of the thorax and bone scan were utilized for metastatic workup. A preoperative angiogram was done in selected cases when tumor invasion of blood vessels was suspected. All patients received neoadjuvant chemotherapy (3 cycles of methotrexate, doxorubicin and cisplatin every 3 weekly) prior to definitive surgery. Surgery was performed 3-4 weeks after the last date of chemotherapy.

Surgical procedure

The surgical approach was through a medial longitudinal incision to expose the popliteal fossa and upper tibia. The anterior and posterior flaps were raised with adequate thickness to avoid skin necrosis. The medial gastrocnemius was retracted posteriorly and the attachment of the medial hamstrings and the soleus were released from the tibia to expose the trifurcation of the vessels. Conventionally, the ATA is ligated and divided at a

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point where it crossed the interosseous membrane. We found that careful dissection along the interosseous membrane could facilitate the preservation of the ATA in several patients where the disease did not extend to this area. The Posterior Tibial Artery (PTA) was identified at the division of the popliteal artery. Using artery forceps and dissecting scissors, the vessel was dissected on its anterior aspect until it arched over the interosseous membrane. The anterior compartment muscles were divided as required for oncological safety and this was extended up to the identification of ATA in the anterior compartment. Once the distal tibial cut was done, the dissection was proceeded up to the interosseous membrane. The muscular divisions were done by lifting the cut tibia that enabled ATA dissection till the point it arches over the interosseous membrane. After the vascular dissection was completed, lateral mobilization of the upper end of the tibia was performed. If the disease didn't extend to the lateral or posterior compartments, the fibular head was preserved. A distal resection margin of 3 cm was used. The custom made prosthesis was used for reconstruction in all cases.

Data collection and statistical analysis

All patients underwent clinical examination, local imaging, chest imaging, and functional assessment at regular intervals. Functional assessment was done using the Musculoskeletal Tumor Society (MSTS) scoring system [4]. 'The scoring system contains 6 items for assessment namely pain, function, emotional acceptance, supports, walking and gait. Each category is scored from 0-5 with a maximum possible score of 30' The score was calculated by a trained physiotherapist and individual scores were converted to percentage values before analysis. The demographic profile, the tumor profile and the details of the surgical procedure were collected from the case records. The data were analyzed using the software SPSS version 22.0 (Armonk, NY: IBM Corp). Karl Pearson's correlation coefficient was used to check the association between continuous variables and a chi-square test to check the association between categorical variables. Student's t-test was used to check the equality of means. Levene's test for equality of variances was used to compare the MSTS scores of the two groups of patients at intervals of 3, 6 and 12 months. Tumour volume before and after chemotherapy was calculated using the MRI scan. Clavien-Dindo scoring system was used to assess the surgical morbidity [5].

RESULTS

Twenty-two patients were included. The demographic profile of the patients, disease profile and details of the surgery are depicted in Table 1.

All patients had negative margins in the final histopathology. The tumor characteristics, demographics and surgical parameters in both groups [i.e. ATA preserved (ATAp) and ATA sacrificed (ATAs) groups] are shown in Table 2.

MSTS scores at three months, six months and one year using Levene's test showed no statistically significant difference in both the groups, although the scores were higher in ATAp (Table 3).

These MSTS scores were not influenced by age, gender,

Variables	Result (n=22)	
Gender	Male	17
	Female	5
	Mean	21.2
Age (years)	Median (range)	12.5 (12-49)
Length of bone resection	Range	10-23 cm
	Mean	15.3 cm
Extra-osseous involvement	Present	9
	Absent	13
Articular involvement	Present	4
	Absent	18
Laterality of the limb	Right	12
	Left	10
Anterior tibial artery (ATA)	Preserved	13
	Sacrificed	9
	Performed	2
Mesh myoplasty	Not performed	20
	≥ 90%	14
Tumor necrosis	<90%	8

Variables	ATAp (n=13)	ATAs (n=9)
Average tumor volume at the surgery	180.2 cm ³	175.2 cm ³
Median tumor volume	192.4 cm ³	104.4 cm ³
The average length of bone resection	15.8 cm	14.8 cm
The median length of bone resection	16 cm	12 cm
Extra-osseous involvement	4 (30.77%)	5 (55.56%)
Articular involvement	2 (15.38%)	2 (22.22%)
Gender	Males (10); Females (3)	Males (7); Females (2)

Duration of follow up	ATA† preservation group	MSTS score (average.)	p-value
At three months	ATAp‡	36.54	0.086
	ATAs§	27.56	
At six months	ATAp	59.54	0.138
	ATAs	46.33	
At one year	ATAp	75.62	0.122
	ATAs	58.89	

*Musculoskeletal tumor society scoring system
 †Anterior tibial artery
 ‡ATA preserved
 §ATA sacrificed

laterality, length of bony resection, articular involvement, extra-osseous involvement and tumor volume before or after chemotherapy. Overall morbidity of the procedure was low (Table 4).

A comparison between the groups with respect to morbidity was not performed as the number of events were small. The median follow up in the entire cohort was 69 months. There was a strong

Tab. 4. Morbidity and Clavian-Dindo category in the entire cohort	Morbidity	N (=22)	Clavien-Dindo class
	None	13	
	Wound edge necrosis/gaping treated with a favorable outcome	1	3A
		3	3B
	Wound infection/gaping requiring prosthesis removal/amputation	2	3B
	Foot drop	3	3A

Tab. 5. Oncological outcomes in the entire cohort and in both groups. p-value of <0.05 is significant	Variable	Total (n=22)	ATAp (n=13)	ATAs (n=9)	p-value
	Overall survival (OS) (estimated at 5 years)	76.5%	90%	57.1%	0.093 (NS)
	Local recurrence	9.09% (n=2)	7.7% (n=1)	11.1% (n=1)	
	Distant metastasis	13.63% (n=3)	7.7% (n=1)	22.2% (n=2)	

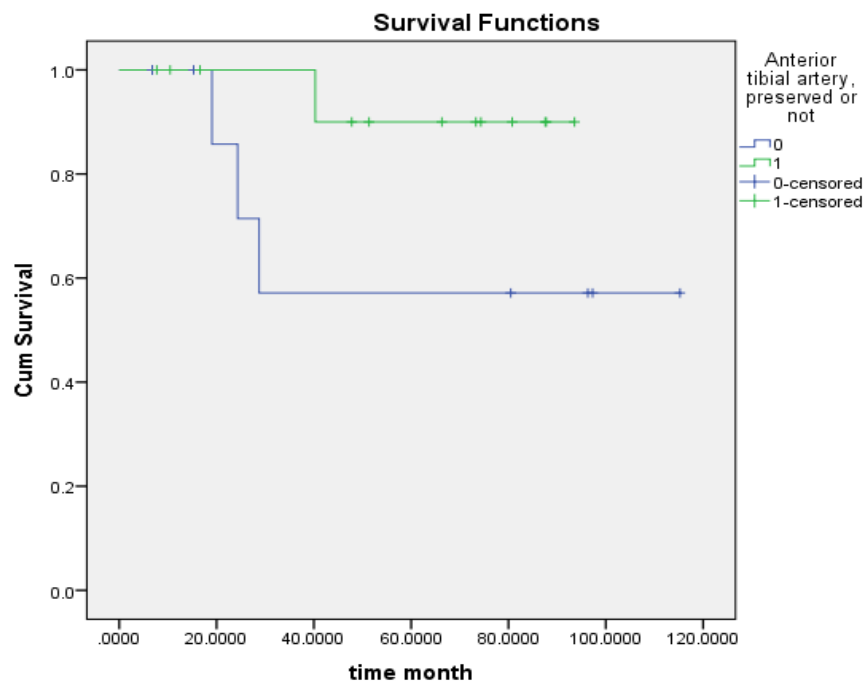


Fig. 1. Estimated 5 year overall survival in both the groups

tendency for improved overall survival at five years for the group ATAp compared to ATAs. However statistical significance was not achieved, probably due to the small number of events (Figure 1). Median survival was not attained. (Table 5).

DISCUSSION

Limb salvage surgery of proximal tibia is difficult due to the complex anatomy of the popliteal region, vascular complexity and difficulty in soft tissue reconstruction. In Limb salvage surgery involving proximal tibial tumors, ATA is usually ligated as it crosses anteriorly and over interosseous membranes [6, 7]. The PTA and peroneal artery (PrA) are usually preserved and serve the blood supply to the conserved limb. In some cases, PrA may require to be ligated and in that case, only PTA will supply the limb. We found that with careful dissection through the interosseous membrane, it is possible to preserve ATA in the majority of the patients with osteosarcoma of the upper tibia. If the disease is not extending to the area of the interosseous membrane where the ATA crosses it, the ligation of the ATA is not necessary. Further vascular dissection is not affected or significantly inconvenienced by the preservation of the ATA. We obtained negative tumor margins in all our patients in the final histopathology. The incidence of

significant morbidity (Clavien Dindo score 3b or above) and the requirement of repeat surgery were comparable between the groups. Zheng et al. studied 471 patients and found anatomical variation in popliteal artery branching is common in normal population and knowledge about it is essential before planning any procedure of lower limb. They found PTA agenesis in 5.9% of the study population and hypoplastic or aplastic PTA in 2.4% [8]. In such situations preservation of ATA is important to avoid potential de-vascularization of the lower limb. Preoperative conventional or digital angiography or more recently computed tomography angiography and magnetic resonance imaging have been used by surgeons as a reference for vascular anatomy before contemplating complex resections of osteosarcoma [9, 10]. This helps in vascular preservation in suitable cases. The overall survival was comparable between ATAp and ATAs. The pattern of local and distant recurrence was also similar, though the comparison is limited by low event rate and retrospective design of the study. The results point to the oncological safety of preservation of ATA by an experienced orthopedic surgical oncologist, in patients where the ATA is not involved by the tumor. A prospective study may be helpful to further clarify the results.

Higher average MSTTS scores were obtained in patients in whom ATA was preserved, consistently, at three months, six months and one year after completion of the treatment. However, the differences did not reach statistical significance [9,10,11]. Other possible confounding factors like tumor volume, length of bone resection, mesh myoplasty, laterality of the limb, extraosseous involvement, post-operative morbidity and repeat procedures were comparable between the groups.

LIMITATIONS OF THE STUDY

Our study is limited by the fact that it is a retrospective study with limited numbers. The events are less for a meaningful oncological comparison. A larger prospective study may answer

the questions related to this better.

CONCLUSION

It is feasible to preserve ATA during limb salvage surgery for proximal tibial tumors in the majority of patients without compromising oncological outcomes. The trend towards better functional outcome was seen with preservation of ATA, but statistical significance was not achieved.

DECLARATIONS

The authors state that they have no conflict of interest.

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