Identifying consensus and areas for future research in chondrosarcoma

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■ ONCOLOGY

Identifying consensus and areas for future research in chondrosarcoma

A REPORT FROM THE BIRMINGHAM ORTHOPAEDIC ONCOLOGY MEETING

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Aims

The Birmingham Orthopaedic Oncology Meeting (BOOM), held in January 2024, convened 309 delegates from 53 countries to discuss and refine 21 consensus statements on the optimal management of chondrosarcoma.

Methods

With representation from Europe (43%; n = 133), North America (17%; n = 53), South America (16%; n = 49), Asia (13%; n = 40), Australasia (5%; n = 16), the Middle East (4%; n = 12), and Africa (2%; n = 6), the combined experience of treating bone sarcomas among attendees totalled approximately 30,000 cases annually, equivalent to 66 years of experience in the UK alone. The meeting's process began with the formation of a local organizing committee, regional leads, and a scientific committee comprising representatives from 150 specialist units across 47 countries. Supported by major orthopaedic oncology organizations, the meeting used a modified Delphi process to develop consensus statements through online questionnaires, thematic groupings, narrative reviews, and anonymous pre-meeting polling.

Results

Strong (> 80%) consensus was achieved on 19 out of 21 statements, reflecting agreement among delegates. Key areas of consensus included the role of radiology in diagnosis and surveillance, the management of locally recurrent disease, and the treatment of dedifferentiated chondrosarcoma. Notably, there was agreement that routine chemotherapy has no role in chondrosarcoma treatment, and radiological surveillance is safe for intraosseous chondrosarcomas. Despite the overall consensus, areas of controversy remain, particularly regarding the treatment of atypical cartilage tumours and surgical margins. These unresolved issues underscore the need for further research and collaboration within the orthopaedic oncology community.

Conclusion

BOOM represents the largest global consensus meeting in orthopaedic oncology, providing valuable guidance for clinicians managing chondrosarcoma worldwide. The consensus statements offer a reference for clinical practice, highlight key research priorities, and aim to improve patient outcomes on a global scale.

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Introduction

In January 2024, 309 delegates from 53 countries participated in a two-day consensus meeting in Birmingham, UK, called the Birmingham Orthopaedic Oncology Meeting (BOOM), to debate researched evidence on 21 consensus statements on optimal management of chondrosarcoma via a modified Delphi process. The delegates represented Europe (43%), North America (17%), South America (16%), Asia (13%), Australasia (5%), the Middle East (4%), and Africa (2%). In the pre-meeting poll, delegates were asked to report the number of new bone sarcomas they see per year. The mean was calculated and then multiplied by the number of delegates to provide an estimated combined experience of treating 30,000

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bone sarcomas per year. Contextually that represents approximately 450 new bone sarcomas seen in the UK each year, indicating the vast global experience of the meeting equating to 66 years of UK experience.

Methods

Of the 309 participants, the majority were orthopaedic oncologists (n = 272; 88%), five (2%) were radiologists, two (1%) were pathologists, and 13 (4%) comprised a diverse group of professionals including PhD students, nurses, and internal medicine specialists.

The process started with developing a local organizing committee, a group of regional leads (one for each continent) and an invited scientific committee of a representative from 150 specialist units from 47 countries. The concept of the international consensus meeting was supported by all major orthopaedic oncology organizations, International Society of Limb Salvage, Musculoskeletal Tumor Society, European Musculoskeletal Oncology Society, Asia Pacific Musculoskeletal Tumor Society, and Sociedad Latinoamericana De Tumores Musculoesqueleticos.

A series of online questionnaires were then used to develop a panel of 120 questions which were ranked in terms of priority by the scientific committee. The highest-priority questions were grouped into ten themes. Each theme was then allocated to two different units from different continents to compile a narrative review of the evidence, grade the strength of the evidence, give a personal/unit perspective on the question, and develop a consensus statement with references to the question, however without using a formal grading of the evidence described by the GRADE framework.[1] An anonymous pre-meeting poll of registered delegates, without disseminating the evidence, was used to gauge the likely level of consensus, to assess the time required for debate of each theme during the meeting, depending upon the level of controversy. Both sets of evidence were collated, and the suggested consensus statements were coalesced with agreement between the evidence gatherers.[2] The evidence booklet contained 200 pages of information (Supplementary Material) and was distributed to all the delegates four weeks prior to the meeting. It is freely available to download at www.boomconsensus.org, together with the results from the consensus meeting, video recording of the meeting, and any scientific outputs from the meeting. No ethical approval was applicable for the consensus meeting.

On the day of the meeting, each session was chaired by a member of the organizing committee, a regional lead. Prof. Bernadette Brennan, a paediatric oncologist who rarely treats chondrosarcoma, was approached to undertake this independent moderator role because she has expertise in developing consensus for the multidisciplinary management of other bone sarcomas, in particular Ewing's sarcoma. Each unit presented a brief overview of the salient points of their research, and the audience debated the proposed consensus statement. If more than 10% of the delegates expressed a wish to change some wording of the statement, this was allowed at the chair's discretion, provided the wording change did not alter the sentiment of the statement or go against the presented evidence. The delegates were then asked to vote to agree/disagree or abstain on the statement (as presented in the results). Abstentions were not counted in the total of the consensus strength, which was rated using the criteria in Table I according to International Consensus Meeting (ICM) criteria.[3] Two authors have subsequently and independently checked the registered votes to ensure no delegates had multiple votes for the same statement. The consensus statements are presented below, with full results available in Table II.

Table I. Birmingham Orthopaedic Oncology Meeting consensus strength categories.

Simple majority (50.1% to 59%)	No consensus
Majority (60% to 69%)	Weak consensus
Large majority (70% to 79%)	Moderate consensus
Super majority (80% to 99%)	Strong consensus
Unanimous (100%)	Unanimous consensus

Results

Radiology of cartilage tumours

Which imaging feature gives the best positive/negative predictive value for differentiating an enchondroma from an atypical chondroid tumour/chondrosarcoma? The presence of soft-tissue extension, cortical destruction, and perilesional oedema on MRI demonstrate high positive predictive value differentiating chondrosarcomas G2/G3 from enchondromas. The absence of endosteal scalloping on CT has high negative predictive value in differentiating enchondromas from chondrosarcomas G2/G3 (98% super majority – strong consensus).

Can chondrosarcoma be safely diagnosed by radiology alone using radiology classifications, e.g. Birmingham Atypical Cartilaginous Tumour Imaging Protocol? Radiological features of concern, including soft-tissue extension, cortical destruction, and perilesional oedema on MRI, demonstrate high positive predictive value in differentiating higher-grade chondrosarcoma from low-grade and benign cartilaginous lesions. Therefore, resection grade (G2 and G3) lesions can be safely diagnosed by radiology classifications alone. However, there remain clinical circumstances in which higher-grade lesions may benefit from biopsy and histopathological confirmation (85% super majority – strong consensus).

Surveillance of chondrosarcoma

What is the optimal clinical and radiological surveillance following chondrosarcoma resection? Should we stratify by risk? Chondrosarcoma surveillance should be stratified by high- and low-risk protocols. Minimum imaging includes radiographs of the chest and affected area. In high-risk patients an MRI of the surgical site and a CT chest could be considered (91% super majority – strong consensus).

Is it safe to undertake radiological surveillance in atypical chondroid tumour? What is the optimal interval between scans and when should we intervene?

Limited evidence suggests that the risk of metastatic disease from atypical chondroid tumour (ACT) is very low and radiological surveillance for ACTs is safe in the medium term, but no protocols exist for the duration or interval of follow-up (92% super majority – strong consensus).

Table II.

Statement	Evidence level	Votes, n	Results (%)			Consensus level (%)
			Agree	Disagree	Abstain	
Radiology of cartilage tumours						
Which imaging feature gives the best positive/negative predictive value for differentiating an enchondroma from an atypical chondroid tumour (ACT)/chondrosarcoma?	Moderate	225	95	2	3	Strong consensus (95% super majority)
Can chondrosarcoma be safely diagnosed by radiology alone using radiology classifications e.g. BACTIP (Birmingham Atypical Cartilaginous Tumour Imaging Protocol)?	Moderate	235	82	14	2	Strong consensus (85% super majority)
Surveillance of chondrosarcoma						
What is the optimal clinical and radiological surveillance following chondrosarcoma resection? Should we stratify by risk?	Low	224	87	9	3	Strong consensus (91% super majority)
Is it safe to undertake radiological surveillance in ACT? What is optimal interval between scans and when should we intervene?	Low/moderate	242	89	8	3	Strong consensus (92% super majority)
Intraosseous ACT/chondrosarcoma						
Do purely intraosseous central cartilage tumours/ACT/ chondrosarcoma metastasize?	Low	218	92	5	3	Strong consensus (95% super majority)
How should we treat intraosseous ACT/chondrosarcoma?	Moderate	230	49	45	6	No consensus (52% simple majority)
Is it safe to avoid biopsy in radiologically typical chondrosarcomas/ACT?	Low/moderate	233	82	15	3	Strong consensus (85% super majority)
Locally recurrent disease						
Does local recurrence influence the prognosis for chondrosarcoma?	Moderate	229	97	1	1	Strong consensus (99% super majority)
How aggressive should we be in treating locally recurrent disease in chondrosarcoma?	Moderate	215	95	3	2	Strong consensus (97% super majority)
Dedifferentiated chondrosarcoma						
How aggressive should we be with surgery on dedifferentiated chondrosarcoma?	Low	215	97	1	2	Strong consensus (99% super majority)
Should we routinely use adjuvant/neoadjuvant chemotherapy with localized de-differentiated chondrosarcoma?	Low	230	87	7	6	Strong consensus (93% super majority)
Surgical margins						
What is a wide margin in chondrosarcoma?	Low	213	74	22	4	Moderate consensus (77% large majority)
Should we vary the attempted surgical margin depending on grade of chondrosarcoma?	Low	211	99	1	0	Strong consensus (99% super majority)
Treatment of inadvertent margins						
Do intralesional margins for high-grade chondrosarcoma increase risk of poor oncological outcomes?	Moderate	215	97	1	2	Strong consensus (99% super majority)
What is the optimal treatment following an inadvertent intralesional margin of a high-grade chondrosarcoma?	Low	216	92	7	1	Strong consensus (93% super majority)
Pathological fractures						
Does pathological fracture influence the outcome for chondrosarcoma?	Low	220	97	1	2	Strong consensus (99% super majority)
Is limb salvage safe in patients presenting with a pathological fracture through chondrosarcoma?	Low	214	91	6	3	Strong consensus (94% super majority)
Pelvic chondrosarcomas						
Do pelvic chondrosarcomas behave more aggressively and therefore should they be treated more aggressively?	Moderate	209	92	4	4	Strong consensus (94% super majority)
Does navigated surgical resection (with jigs or computer navigation) of chondrosarcoma of pelvis result in better oncological outcomes?	Low	211	93	4	3	Strong consensus (96% super majority)
Adjuvant treatment						
What is the role of adjuvant therapy (radiotherapy/proton beam therapy/carbon ion/chemotherapy) in conventional chondrosarcoma?	Low	209	86	10	4	Strong consensus (90% super majority)
Is there a role for alternate treatments in chondrosarcoma (e.g. cryoablation/radiofrequency ablation (RFA)/ extracorporeal irradiation and reimplantation (ECRI))?	Low	209	90	6	4	Strong consensus (94% super majority)

Intraosseous ACT/chondrosarcoma

Do purely intraosseous central cartilage tumours/ACT/chondrosarcoma metastasize? The metastatic potential of purely intraosseous cartilage tumours is negligible, and an extraosseous mass is a significant prognostic marker for metastatic potential (95% super majority – strong consensus).

How should we treat intraosseous ACT/chondrosarcoma? Purely intraosseous atypical cartilaginous tumours/low-grade chondrosarcoma of the appendicular skeleton can be safely monitored with imaging. For those patients with documented radiological progression or new symptoms of pain attributed to the lesion, curettage is a reasonable option but is associated with a higher risk of local recurrence. Up to 40% of intraosseous lesions will be grade 2 or greater, and curettage in this group may decrease disease-specific survival. En bloc resection with margins lowers the risk of local recurrence but has a higher risk of surgical complications (52% simple majority – no consensus).

Is it safe to avoid biopsy in radiologically typical chondrosarcomas/ACT? Biopsies are no more accurate than conventional forms of radiology at differentiating between benign and malignant central cartilage tumours and may underestimate the final grade of the tumour. Radiological scoring systems give sufficient data to identify low-grade or high-grade chondrosarcomas. Chondrosarcomas can be managed safely without preoperative histological diagnosis in a multidisciplinary team (MDT) setting. To warrant wide resection, a biopsy can be performed to confirm the diagnosis of chondrosarcoma in cases when MRI is not conclusive. Proceeding without a biopsy prior to treatment with either observation or definitive treatment does not appear to affect a patient's risk of local disease progression or local recurrence (85% super majority – strong consensus).

Locally recurrent disease

Does local recurrence influence the prognosis for chondrosarcoma? Local recurrence adversely impacts survival and patient outcomes in conventional chondrosarcoma of bone, regardless of tumour grade. These effects are more pronounced in G2 and G3 tumours. Prolonged survival is possible after local recurrence in low-grade chondrosarcoma. Local recurrence can be reduced by attention to adequacy of surgical margin (99% super majority – strong consensus).

How aggressive should we be in treating locally recurrent disease in chondrosarcoma? Local recurrence should be aggressively treated with wide excision if after restaging there is no evidence of metastatic disease. If mutilating surgery is required to achieve this, patients should be aware of a high rate of local or distant relapse, despite aggressive treatment. In cases of metastatic disease treatment should aim to maintain function and quality of life (97% super majority – strong consensus).

Dedifferentiated chondrosarcoma

How aggressive should we be with surgery on dedifferentiated chondrosarcoma? Dedifferentiated chondrosarcoma is a very aggressive disease with a higher proportion of patients presenting with pathological fracture or metastatic disease, however approximately 25% patients will be alive at five years. Surgery should have a curative intent for patients presenting with isolated disease. There appears to be no difference in survival between limb salvage surgery or amputation, but obtaining wide margins improves disease-free survival, therefore if limb salvage surgery cannot achieve wide margins, then amputation should be considered (99% super majority – strong consensus).

Should we routinely use adjuvant/neoadjuvant chemotherapy with localized dedifferentiated chondrosarcoma? Neoadjuvant/adjuvant chemotherapy for localized de-differentiated chondrosarcoma, in the absence of contraindications, may improve outcomes in limb tumours, however the evidence remains limited. The routine use of neoadjuvant/adjuvant chemotherapy for localized pelvic dedifferentiated chondrosarcoma has less evidence in the literature (93% super majority – strong consensus).

Surgical margins

What is a wide margin in chondrosarcoma? A wide surgical margin should take into account the chondrosarcoma subtype. For low-grade conventional and peripheral chondrosarcoma, a clear soft-tissue margin (> 1 mm) is safe, however for high-grade and dedifferentiated chondrosarcoma, a wider margin of several mm of normal soft-tissue (ideally > 4 mm) results in better oncological outcomes (77% large majority – moderate consensus).

Should we vary the attempted surgical margin depending on grade of chondrosarcoma? Currently, standard practice suggests that intralesional or narrow margins are acceptable for low-grade appendicular tumours and high-grade tumours require wide margins. However, predicting the grade of the tumour preoperatively is difficult. Preoperative decisions on attempted margins should take into account clinical behaviour, image findings, patient choice, and histological diagnosis, if obtained (99% super majority – strong consensus).

Treatment of inadvertent margins

Do intralesional margins for high-grade chondrosarcoma increase the risk of poor oncological outcomes? Intralesional margins for high-grade chondrosarcoma significantly increase the risk of local recurrence and metastases, however both can occur even when wide margins are achieved (99% super majority – strong consensus).

What is the optimal treatment following an inadvertent intralesional margin of a high-grade chondrosarcoma? Following inadvertent intralesional margins in high-grade chondrosarcoma, two strategies exist: either attempt second surgery to achieve wide margins, or close observation in a referral centre and then adequate treatment of any local recurrence. The addition of postoperative radiotherapy may be considered (93% super majority – strong consensus).

Pathological fractures

Does pathological fracture influence the outcome for chondrosarcoma? Pathological fractures may represent a more aggressive form of chondrosarcoma and result in increased rates of locally recurrent disease. However, the influence on survival is less clear, especially in high-grade and dedifferentiated chondrosarcoma (99% super majority – strong consensus).

Is limb salvage safe in patients presenting with a pathological fracture through chondrosarcoma? Pathological fractures may represent a more aggressive form of chondrosarcoma and limb salvage may result in a higher rate of local recurrence.

Margins should not be compromised to achieve limb salvage surgery in the presence of a pathological fracture, but amputation does not offer a survival advantage. Therefore, limb salvage surgery may be safe if wide margins can be achieved, or the patient wishes to avoid an amputation (94% super majority – strong consensus).

Pelvic chondrosarcomas

Do pelvic chondrosarcomas behave more aggressively and therefore should they be treated more aggressively? Central pelvic chondrosarcomas are more likely to have worse prognostic factors and poorer oncological outcomes than chondrosarcomas of the limbs. Surgical treatment is generally recommended and should aim for wide margins with a cuff of normal tissue for the soft-tissue margin (ideally > 2 mm) and a wide bony margin (ideally 1 cm) where achievable (94% super majority – strong consensus).

Does navigated surgical resection (with jigs or computer navigation) of pelvic chondrosarcoma result in better oncological outcomes? Navigated surgical resection (with jigs or surgical navigation) of pelvic chondrosarcoma may result in more accurate bone margins in selected patients and reduce local recurrence. However, the long-term impact on oncological outcomes remains unknown (96% super majority – strong consensus).

Adjuvant treatment

What is the role of adjuvant therapy (radiotherapy/proton beam therapy/carbon ion/chemotherapy) in conventional chondrosarcoma? Complete surgical resection remains the main treatment in chondrosarcoma. There is some evidence that radiotherapy or heavy ion therapy may be of benefit following margin positive surgery in high-grade tumours and unresectable tumours. There is no evidence for the use of chemotherapy (90% super majority – strong consensus).

Is there a role for alternate treatments in chondrosarcoma (e.g. cryoablation/RFA/ECRI)? Cryotherapy may be a useful adjunct to curettage for low-grade limb chondrosarcoma. Extracorporeal irradiation (ECRI) is a safe treatment for all grades of chondrosarcoma. Percutaneous radiofrequency ablation (RFA) and cryoablation have limited role in treatment of primary tumours but may have a role for palliation (94% super majority – strong consensus).

Cryoablation is a procedure that involves the use of extreme cold to destroy tissue. It is performed using hollow needles, known as cryoprobes, through which cooled, thermally conductive fluids are circulated. Cryotherapy encompasses various treatment for tissue, whether superficial or deep, local or general, with cryoablation being one specific example of cryotherapy.

Discussion

The results from the consensus meeting are quite remarkable, with strong consensus being achieved in 19 out of 21 questions. The delegates were extremely engaged in the process. Although 267 delegates were registered to vote, the maximum number of votes achieved was 242. Generally, delegates voted on 85% (6,141/7,220) of the statements. The authors feel that this discrepancy is likely because of the inherent composition of the participants. A number of delegates were trainees, allied health care professionals, and observers, and chose not to vote. As the meeting included multidisciplinary specialists comprising of radiologists, pathologists, and surgeons, some delegates felt uncomfortable voting on questions outside their field of expertise and either abstained or did not vote. Lastly, given the global nature of the meeting, some delegates arrived later or only attended part of the sessions and hence may have missed an opportunity to vote. The authors therefore feel that the voting process was valid and representative of the delegates' views, reinforced by the strong majority vote achieved in 19 out of 21 statements. Further research is being conducted into the ethical robustness of the consensus meeting.

Key areas of consensus

Radiology of chondrosarcoma and preoperative biopsy. The evidence researched showed that a combination of MRI and CT can accurately diagnose the difference between benign cartilage lesions, low-grade cartilage lesions, and higher grades of chondrosarcoma in a multidisciplinary discussion. A variety of radiological scoring systems such as the Birmingham Atypical Cartilaginous Tumour Imaging Protocol and Radiological Aggressiveness Score (RAS) have been recently published,[4,5] and RAS has shown to have a higher sensitivity and specificity at diagnosing low- from high-grade chondrosarcoma compared to a core needle biopsy. The delegates showed strong consensus that using radiology in a MDT setting can safely diagnose, monitor, and make treatment decisions in suspected chondrosarcoma cases without proceeding to a biopsy, unless the treating clinician wishes. This is a move away from biopsy being the reference standard in the field and is due primarily to recent evidence of the poor correlation between the grade of chondrosarcoma demonstrated at biopsy compared to final histology.[6–8]

Purely intraosseous chondrosarcoma. Recent published multicentre evidence reported that cartilage tumours that have not breached the cortex of the bone have a negligible risk of metastases at that point in time,[9] and the delegates voted with strong consensus to this statement. This is an important change in perception of the evolution of more patient-specific treatment strategies. This reinforces the idea that a strategy of active radiological surveillance of the lesion or surgical treatment (which is potentially curative) at that stage is reasonable depending on patient preference.

Locally recurrent disease. There was strong consensus that locally recurrent disease negatively impacts patient outcomes including disease-specific survival. Local recurrent disease should be treated aggressively if isolated. Moreover, local recurrence can be reduced by attention to surgical margins at primary surgery. Although this sounds logical, opinion has previously been mixed on the link between local recurrence and reduced patient survival.[10,11] The delegates confirmed with strong consensus the link between margins, local recurrence, and reduced patient survival which has been reported in the literature.

Adjuvant therapy in chondrosarcoma. The delegates voted with strong consensus that the current evidence suggests that chondrosarcoma is primarily a surgically treated disease, there is no role of routine chemotherapy (with the exception of appendicular dedifferentiated chondrosarcoma), and forms of radiotherapy may have a limited role in specific circumstances.

Areas requiring focused research

Two areas of controversy still exist despite the evidence being researched and openly debated. The BOOM consensus group will continue to work on these areas and research proposals are currently being developed within the collaborative network.

Treatment of atypical cartilage tumours or axial intraosseous chondrosarcoma. Global disparity was evident in the treatment of intraosseous cartilage tumours. The debate between observation of the lesion, treatment by intralesional curettage, or wide resection was vigorous, with strong opinions expressed for particular strategies. Evidence exists for surveillance or both surgical treatments, and while the statement tried to encapsulate the advantages and risks of all treatment strategies, the delegates could not gain consensus on the statement. The debate was dichotomous with geographical variation evident; proponents of each specific treatment strategy remained entrenched in their position and disagreed with part or all of the statement. This was one of the most controversial outcomes of the meeting; despite being a negative experience, it has allowed a clear research question which is being refined into a formal proposal which the group can potentially answer in the future.

Surgical margins. Attempting to define surgical margins more accurately for future research was an important aim for the meeting. The questions on defining margins for different subtypes and grades of tumour gained moderate consensus, but 22% of the votes disagreed with the statement. The debate considered the reported low evidence base for the statement and a general concern that numerical measurement of thickness of surgical margins may have medicolegal consequences. Some delegates expressed discomfort with the definition of wide margins, particularly in the context of low-grade lesions. Despite the question specifically addressing wide margins, these delegates indicated that they would still consider intralesional procedures acceptable for such cases, highlighting ongoing controversy in this area. The definition of wide margins for chondrosarcomas in the pelvic location had strong consensus. The fact that moderate consensus was achieved allows future research to report outcomes to the BOOM statement. It may, even if in part, allow more meaningful comparison of margins in future research. However, units that do not measure the numerical width of margin may wish to pursue the question as part of a collaborative study.

Conclusion

BOOM was the largest global consensus meeting in orthopaedic oncology with representation from a broad spectrum of clinicians (including orthopaedic surgeons, pathologists, radiologists, and oncologists) across the globe working in diverse scenarios treating chondrosarcoma. Strong consensus was achieved in 19 out of 21 statements on significant day-to-day problems in managing patients with chondrosarcoma. The consensus is a good reference for clinical practice. The orthopaedic oncology surgeons and MDT members may correlate the information with the available facilities of their centres. The authors believe it will allow key research areas to be addressed in future studies, allow a network for future collaboration, and has created some definitions which may allow more meaningful reporting of results. Most importantly, the group hopes these statements will help clinicians managing chondrosarcoma, and therefore improve the outcomes for patients around the globe.

Take home message

- The Birmingham Orthopaedic Oncology Meeting (BOOM) successfully achieved strong consensus (> 80%) on 19 out of 21 statements regarding chondrosarcoma management, reflecting global agreement on critical aspects such as radiological diagnosis, surveillance, and the treatment of dedifferentiated chondrosarcoma.
- Despite the consensus, ongoing controversies, particularly related to the treatment of atypical cartilage tumours and surgical margins, highlight the need for further research and international collaboration within the orthopaedic oncology community.

Supplementary material

BOOM consensus meeting participants.

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