

Cone beam CT for paranasal sinus and temporal bone: A cost-benefit analysis in Singapore

Kelvin Yong Jie Lim^{*1} MMED (ORL), Jian Li Tan^{*1} FAMS (ORL), Alvin Yong Quan Soon² FRCR (UK), Lay Wai Khin³ PGC, Ming Yann Lim¹ FAMS (ORL), Seng Beng Yeo¹ FAMS (ORL)

Dear Editor,

Cone beam computed tomography (CBCT) has emerged as a valuable imaging tool in otorhinolaryngology or the specialty of ear, nose and throat (ENT), where precise imaging of the sinus and temporal bone pathologies is essential. This paper presents a cost-benefit analysis (CBA) of CBCT in a public healthcare setting, and highlights its monetary and non-monetary benefits—to our knowledge, the first study on these in the Singapore context and in literature. The findings offer insights for policymakers on the feasibility of adopting CBCT as a primary radiological tool in ENT.

This prospective CBA was conducted at Tan Tock Seng Hospital, a tertiary care centre in Singapore, from January 2022 to October 2023. The study included patients aged 18 years and older, who required CBCT or multi-detector computed tomography (MDCT) imaging of the paranasal sinuses or temporal bone. The CBCT machine used was the GiANO HR scanner (NewTom, Italy), while the MDCT machine was the GE CT Revolution Apex 2.2 scanner (GE Healthcare, US). Both machines, purchased 2 years apart, were the closest comparators available and operated under standardised imaging protocols.

Table 1. Comparative cost analysis of CBCT and MDCT.

Metric	CBCT	MDCT	Savings
Average cost per scan, SGD	\$187.50	\$475.13	\$287.63
Annual patient savings (for 518 scans), SGD	\$97,125	\$246,117.34	\$148,992.34
Machine cost per year, SGD	\$33,558.43	\$572,358.43	\$538,800.00
Total annual savings, SGD	-	-	\$688,079.97
Radiation dose, µSv	63	108	42% reduction
Space requirement, m ²	2.59	25	90% reduction
Waiting time for scan, weeks	3	10	7 weeks
Machine type			
Machine cost (after amortisation), SGD	\$22,857.14	\$285,714.29	\$262,857.15
IT testing and integration, SGD	\$7787.00	\$7787.00	0
Renovation cost, SGD	\$1714.29	\$42,857.14	\$41,142.85
Maintenance cost, SGD	\$1200.00	\$236,000.00	\$234,800.00
Manpower cost (1 radiologist and 1 radiographer)	Negates each other		
Cost calculations (hospital's perspective): machine cost per year, SGD	\$33,558.43	\$572,358.43	\$538,800.00

CBCT: cone beam computed tomography; IT: information technology; MDCT: multi-detector computed tomography; SGD: Singapore dollars

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¹ Department of Otorhinolaryngology, Tan Tock Seng Hospital, Singapore
² Department of Diagnostic Radiology, Tan Tock Seng Hospital, Singapore
³ Department of Clinical Research and Innovation Office, Tan Tock Seng Hospital, Singapore
^{*} Joint first authors

Correspondence: Dr Kelvin Yong Jie Lim, Department of Otorhinolaryngology, Tan Tock Seng Hospital, 11 Jalan Tan Tock Seng, Singapore 308433.
Email: limyjk@gmail.com
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Cost-benefit analysis. Examining patient cost savings, the average cost of a CBCT scan was SGD187.50, compared to SGD475.13 for MDCT, yielding a saving of SGD287.63 per scan. With a switch from MDCT to CBCT for ENT-related scans, patients could save about SGD148,992.34 per year, based on 518 scans annually.

Examining hospital cost savings, the amortised machine cost over 7 years for CBCT was SGD22,857.14, compared to SGD285,714.29 for MDCT. Maintenance costs were markedly lower for CBCT at SGD1200 annually versus SGD236,000 for MDCT. Additional overheads, including information technology (IT) integration and renovations, further highlighted CBCT's economic efficiency. The total annual hospital cost of CBCT was SGD33,558.43, compared to SGD572,358.43 for MDCT, resulting in net hospital savings of SGD538,000. Combined with patient savings, the total annual cost saving was SGD687,792.34.

Examining the benefit-cost ratio (BCR), which is a key metric in economic viability, the BCR for CBCT was 16.06, meaning for every dollar spent, the hospital achieved a return of SGD16.06 in cost savings. This underscores CBCT's financial feasibility for high-volume ENT imaging needs.

Clinical advantages of CBCT. In sinus imaging applications, CBCT is particularly advantageous due to its low radiation dose¹ and high-resolution visualisation of crucial bony landmarks like the uncinate process and skull base. This is critical for chronic rhinosinusitis assessment and surgical planning.²

In intraoperative CBCT in endoscopic sinus surgery (ESS), CBCT has been used intraoperatively for ESS, particularly in the frontal recess. Studies have shown its value in refining surgical strategies and optimising stent placements via a C-arm CBCT.³ At our institution, CBCT images have been integrated into the Stealthstation S8 (Medtronic, Dublin, Ireland) surgical navigation system, enhancing intraoperative precision.⁴ However, our CBCT machine is not a C-arm CBCT and does not offer real-time imaging during surgery.

In temporal bone imaging, CBCT offers superior resolution for fine bony structures in the middle and inner ear compared to MDCT. It also significantly reduces metal artefacts, making it valuable for postoperative imaging of cochlear and middle ear implants. Studies report up to a 60-fold radiation dose reduction compared to MDCT, particularly with a limited field-of-view protocol.

In postoperative imaging of cochlear and middle ear implants, CBCT allows for accurate visualisation

of electrode arrays and their modiolus relationship in cochlear implants. It also reduces metal-related artefacts, improving imaging clarity compared to conventional CT.

In detecting histologically active otosclerosis, CBCT is highly sensitive, with 100% sensitivity in identifying active lesions, particularly hypodense fenestral lesions at the stapes footplate's anterior pole. However, it cannot detect inactive otosclerosis, necessitating careful clinical correlation.

For accessing conductive hearing loss, CBCT provides superior image quality and spatial resolution compared to MDCT while delivering up to 70% lower radiation dose, making it a safer and more efficient imaging option.

Limitations and considerations. Our current CBCT system does not support intravenous contrast, limiting its use for tumour or vascular pathology evaluations. However, most ENT-related imaging does not require contrast, and magnetic resonance imaging (MRI) can address this gap. In our cohort, 37 patients (3.9%) who initially underwent CBCT subsequently required MDCT or MRI due to motion artefacts or complex pathology.

CBCT requires patients to remain still for 20–30 seconds, which may not be suitable for those with cognitive impairments. Image artefacts can also obscure subtle radiological findings, particularly in middle ear scans, due to interference from thick scalp tissue and mastoid bone.

Cost calculations assumed a 1:1 ratio of subsidised to private scans. However, subsidised scans account for approximately 70%, meaning the actual average cost per scan might be slightly lower than calculated. Future studies should refine these estimates by incorporating patient demographics and funding structures.

CBCT systems vary widely in specifications, with over 85 models reported in 2018.⁵ Each system has unique features, meaning findings for one system may not generalise to others. Future research should evaluate multiple CBCT models to provide a broader assessment of cost-effectiveness and clinical utility across different healthcare settings.

Economic viability. The findings strongly support CBCT's economic viability in public healthcare. By replacing MDCT for selected indications, CBCT offers substantial cost savings without compromising diagnostic accuracy. These savings can be reallocated to other critical areas, thus enhancing healthcare delivery.

With lower acquisition and maintenance costs, CBCT requires only 18% of the space needed for an

MDCT machine and operates on standard 220/240-volt outlets, reducing renovation costs. Its affordability makes it an ideal choice for public hospitals operating under budget constraints. CBCT could also be integrated into other specialties, such as orthopaedics and maxillofacial surgery, though further research is needed to address subspecialty-specific requirements.

Practical implications. During the study period, waiting times for MDCT scans averaged 10 weeks, compared to just 3 weeks for CBCT. By diverting ENT-related scans to CBCT, hospitals can alleviate pressure on MDCT machines, thus reducing waiting times and improving patient throughput.

CBCT delivers 42% lower radiation than MDCT, aligning with the “as low as reasonably achievable principle”^{6,7} and reducing long-term radiation risks for patients.⁸

This CBA demonstrates the economic and practical advantages of CBCT in public healthcare. With annual cost savings exceeding SGD687,000 and a BCR of 16.06, CBCT is a highly cost-effective alternative to MDCT for ENT imaging. Beyond monetary benefits, CBCT offers reduced radiation exposure, shorter waiting times and streamlined infrastructure requirements, thus enhancing both patient safety and hospital efficiency.

Policymakers should consider prioritising CBCT for high-volume, non-contrast imaging needs. By adopting cost-effective technologies like CBCT, public healthcare systems can optimise resources, improve patient outcomes and achieve long-term sustainability.

Ethics statement

Not applicable.

Declaration

The authors declare they have no affiliations or financial involvement with any commercial organisation with a direct financial interest in the subject or materials discussed in the manuscript.

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