RESEARCH ARTICLE

An audit and service evaluation of the use of cone beam computed tomography (CBCT) in a paediatric dentistry department

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Objectives: CBCT exposes the paediatric patient to a higher X-ray dose and risk than normal dental radiographs. This study has two components: an audit and service evaluation. The audit aims to assess whether the use of CBCT in a Paediatric Dentistry department at a London hospital complies with European guidelines (SEDENTEXCT). The service evaluation aims to explore the influence of CBCT on treatment planning.

Methods: Two 6 month audit cycles were completed, where CBCT requests were audited to check whether image justifications comply with SEDENTEXCT. For the service evaluation, a total of 50 patient records were examined for the effect of CBCT on definitive treatment plans.

Results: The first audit demonstrated 94% compliance with SEDENTEXCT. After instituting staff training in CBCT, compliance improved to 100%. In the service evaluation, 100% of CBCTs were found to provide information that impacted on the clinicians' treatment planning, diagnosis and/or management. Of most significance, 44% of treatment plans were changed because of new information provided by CBCT.

Conclusions: There are few studies investigating the use of CBCT in paediatric dentistry and the impact of this investigation. This service evaluation shows that CBCT can play an important role in optimising paediatric patient outcomes. The need for robust staff training in CBCT referrals to prevent over prescription is demonstrated in the audit cycles.

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Introduction

CBCT is a radiological procedure using divergent X-rays that form a cone-shaped beam. Up to 600 basis X-ray images can be made, and are then combined together to form a three-dimensional representation of the target area.¹ As a result of the number of X-ray images taken per scan, the level of ionising radiation can be much higher than more frequently used two-dimensional dental radiographs. The International Commission on Radiological Protection (ICRP) states that the use of dental CBCT for paediatric patients is a concern due to the patients' higher radiosensitivity and smaller size. ICRP also states that due to the larger relative coverage

of the child's head, effective doses are higher compared with adults if exposure factors are not adapted.² The risk of ionising radiation to a growing thyroid gland is always a concern, with the lifetime mortality risk from a CBCT being estimated between 0.001 and 0.002% based on laboratory phantom studies.³ For this reason, being able to justify using CBCT in children is crucial in patient risk reduction. Justification is both an ethical requirement, as described by the International Atomic Energy Agency (IAEA),⁴ and a legal requirement in the United Kingdom as stated in the Ionising Radiation (Medical Exposure) Regulations (IRMER) 2017.⁵

Since the late 1990s, taking a CBCT in adolescents has become available for orthodontics and oral and maxillofacial surgery.⁶ There is less known about the

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utilisation of CBCT in specialist paediatric dentistry. Therefore, this project aims to explore the use of CBCT in a paediatric dentistry department where there has been a shift in clinical practice and an increase in the number of CBCTs requested. This is likely to reflect a shift in clinical practice experienced by other paediatric dental departments in the region and beyond, suggesting that CBCTs are becoming more frequently utilised in children's dentistry.

Aims

There are two aims of this project:

- (1) Audit: to measure the compliance of CBCT requests made by paediatric dentists with the justification criteria stated in the SEDENTEXCT guidelines.
- (2) Service evaluation: to evaluate whether CBCT results influence treatment plans and patient management in paediatric dentistry.

Methods and Materials

The local research authority classifies this project as an audit and service evaluation; therefore ethical approval was not required and not sought. Throughout both the audit and service evaluation, all patient records were anonymised and no identifiable information was recorded. Strict measures to safeguard patient confidentiality and information governance were practiced during the data collection process.

Audit

The audit took place in a paediatric dentistry department at Guy's & St Thomas' Hospitals, London. This is a tertiary care unit, carrying out specialist-level paediatric dentistry within the South-East of England. On average, the department sees 108 patients a week for clinical assessments and approximately 1% of these are referred for CBCT scans. Therefore, most of the radiographic examinations made for this group of patients are plain images.

The audit measured the compliance of CBCT justifications with the standards set by the SEDENTEXCT guidelines (Radiation Protection No.172).⁷ SEDENTEXCT was a European Commission project that created evidence-based guidelines on the appropriate use and justification of CBCT in dentistry.

The data was collected retrospectively. The inclusion and exclusion criteria were:

- Age of the patient must be 17 or younger.
- The CBCT must have been requested by a paediatric dental consultant, and not by another specialty (*e.g.* orthodontics or cleft services)

The first audit cycle comprised all eligible CBCTs requested between 10 April 2017 and 10 October 2017, totalling 31 requests. The second cycle comprised all eligible CBCTs requested between 26 October 2017

and 25 April 2018, totalling 25 requests. This allowed approximately 2 weeks between the two cycles to analyse the data and implement a plan of action: awareness of the SEDENTEXCT guidelines was raised via a departmental seminar attended by the trained CBCT referrers, and an IRMER update course was also provided.

Service evaluation

The service evaluation examined all the CBCT cases collated in both audit cycles. Patient records were investigated comparing the provisional treatment plan made before the CBCT was taken, with the definitive treatment plan made post-CBCT.

The inclusion and exclusion criteria were as follows:

- To include all CBCTs in the audit deemed to be justified according to SEDENTEXCT.
- To exclude cases where the CBCT was yet to be reviewed by the referring clinician, and a definitive treatment plan had not yet been made.

In total, 56 CBCT examinations were made during the audit period. For the service evaluation, two were excluded because they were non-compliant with the SEDENTEXCT guidelines; four were excluded because the definitive treatment plan had not been made at the time of data collection. Therefore, 50 CBCTs were included in the service evaluation.

For the 50 cases included in the service evaluation, plain radiographs were always taken prior to CBCT for the initial assessment, diagnosis or review of treatment response. Each patient was prescribed a combination of intraoral periapicals, occlusal views and/or panoramic views. Clinicians requested CBCT to provide further information that would affect patient management when plain imaging was insufficient or inconclusive.

Results

Audit

The CBCTs reviewed in the project covered a wide range of clinical indications as shown in Table 1. Examinations were most commonly requested for the assessment of unerupted teeth (23%), supernumeraries (21%) and

Table 1 Audit: clinical indications for the CBCTs used in both audit cycles

Clinical indication	No. of indications	% total
Root resorption	8	14%
Dental trauma	4	7%
Bony pathology	11	20%
Supernumerary teeth	12	21%
Unerupted teeth	13	23%
Pulp anatomy	5	9%
Surgical planning	3	5%

bony pathosis (20%). The age of subjects range between 5 and 17 years old, with a mean of 11.5 years.

The first audit cycle showed the department to have a compliance of 94%: two CBCTs were not justified according to the SEDENTEXCT project. Reasons for non-compliance include not attempting two-dimensional plain films prior to CBCT, and taking CBCT when plain films had already answered the clinical question. An action plan was implemented to improve staff training in the use and justification of CBCT. The second audit cycle showed an acceptable improvement: 100% of CBCTs taken by paediatric dentistry were compliant with SEDENTEXCT.

No differences were observed in the types of plain imaging used prior to CBCT when comparing the first and second cycles. A combination of intraoral periapicals, occlusal views and/or panoramic views were always taken depending on each patient's clinical assessment, excluding the non-compliant case where plain films were not prescribed.

Service evaluation

The most common clinical indication for the 50 CBCT examinations reviewed was for the assessment of unerupted teeth (23%). The mean age of subjects was 11 years old.

The results show that 100% of the CBCTs taken influenced the definitive treatment plans and/or diagnosis made by clinicians. Most significantly, 44% of treatment plans were changed following CBCT examination. Details of these changes are presented in

Table 2. The remaining 56% of provisional treatment plans were confirmed by new information provided by CBCT, increasing the clinician's confidence in diagnosis and direct management.

The two CBCTs that were excluded from the service evaluation due to non-compliance with the audit's gold-standard did not alter patient management. The first excluded CBCT was taken for a suspected root dilaceration due to a clinically palpable lump. The CBCT showed normal root formation and no abnormalities. This could have been elicited from an intraoral periapical and/or upper standard occlusal in the first instance, but plain imaging was never attempted. The second excluded CBCT was prescribed to assess the periapical tissue around a non-vital incisor. A provisional treatment plan of endodontic therapy had been made after taking plain radiographs that clearly visualised an associated periapical radiolucency. The CBCT that was then taken added no extra information to diagnosis and the patient proceeded to have endodontic treatment to the non-vital tooth.

Discussion

Audit

This project provides insight into the use of CBCT in the specialty of Paediatric Dentistry. The audit emphasises the importance of training clinicians appropriately, evidenced by the improved standards in the second cycle. This corroborates the European Academy of

Table 2 Service evaluation: a table summary of the service evaluation findings

Treatment plan changed following CBCT	No. of patients
Pre-CBCT plan was to extract permanent tooth:	10
• Changed to root canal therapy (or enucleation) instead	
• Changed the tooth number for extraction	
• Changed to orthodontic repositioning of tooth instead	
Pre-CBCT plan was to monitor tooth and not intervene:	4
• Changed to root canal therapy	
• Changed to surgical exploration	
• Changed to crown separation (double tooth identified by CBCT)	
• Changed to surgical exposure	
Referred to other specialties due to complicating factors identified by CBCT such as complex pulpal anatomy and infra-bony lesions.	4
CBCT revealed pathology which could not be seen on plain films:	2
• Cyst identified: enucleation added to treatment plan	
• Orofacial infection found to have dental origin: extraction added to plan.	
Provisional plan was to carry out root canal therapy on a permanent tooth:	1
• CBCT revealed pathology associated with root of deciduous tooth, so this was planned for extraction instead.	
Provisional diagnosis of ectopic molar considering exposure and orthodontic alignment—CBCT identified an odontome impeding its eruption	1
• Plan changed to removal of odontome	
TOTAL	22/50 (44%)
Treatment plan confirmed following CBCT	No. of patients
Provided guiding information for surgical approach (localised teeth for surgical extraction; confirmed if teeth are safe to extract; identified and localised supernumerary teeth or odontomes)	26
Confirmed that teeth are of poor prognosis and were suitable for extraction	2
TOTAL	28/50 (56%)

DentoMaxilloFacial Radiology (EADMFR) position statement in 2014, which advises formal “Level 1” training for referring dentists in the use of CBCT to reduce the risk of over-prescription.⁸ Clinicians who receive “Level 2” training will report on the CBCT examination. Justification is often the role of an oral & maxillofacial radiologist, acting as the designated “practitioner”. However, to ensure a high standard of patient risk reduction, both the referrer and practitioner should be involved in the case selection from the outset.

The SEDENTEXCT CBCT selection criteria guidelines are based on weak levels of evidence; mainly expert opinions and consensuses. However, acknowledging the lack of randomised controlled experimental research in CBCT, the SEDENTEXCT project is still regarded as among the most robust guidance available to audit standards of practice against.

Service evaluation

There has been limited research in the use of CBCT in paediatric dentistry in the United Kingdom, particularly work that addresses the higher levels of evidence of efficacy and impact of an imaging modality.⁹ This study is the first to explore the effect that CBCT has on paediatric treatment plans. There have been a number of case reports, case series and reviews which demonstrate the value CBCT can have in paediatric patients for orthodontic purposes. This service evaluation is novel in that it presents data encompassing a range of other clinical problems focussed within the specialty of Paediatric Dentistry instead.

A service evaluation carried out by Hidalgo-Rivas *et al* in 2014 explored the indications and radiological properties of 294 CBCTs requested by paediatric dentists across three dental hospitals.¹⁰ In agreement with the present study, they conclude that CBCTs are most commonly requested for localising unerupted teeth, supernumeraries and assessing root resorption. This department is, on average, performing CBCT examinations on slightly younger patients (mean age: 11 years) as opposed to the service evaluation by Hidalgo-Rivas *et al* (mean age: 13 years). This may be explained by the fact that orthodontic CBCT examinations, which often involve older adolescents, were included in the latter but not in the present study.

The results of the service evaluation demonstrate the value that CBCT examinations have had in the Paediatric Dental Department at Guy's & St Thomas' Hospitals, evidenced by effecting change in 44% of treatment plans. Most of these plans have been changed significantly, helping to avoid misdiagnoses and treatment errors such as extracting sound teeth. For example, [Figure 1](#) shows a CBCT section of a cyst that was not visible on the radiograph taken previously. This was then planned for enucleation. In another case, CBCT revealed a nasopalatine duct cyst that was previously thought to be periapical pathology associated with an upper central incisor ([Figure 2](#)). This meant that the

Figure 1 CBCT images visualise a cyst buccal to the upper right central incisor tooth. An upper surface occlusal radiograph taken previously is seemingly clear of bony pathology.

original treatment plan to extirpate the incisor was changed, and a vital permanent tooth was saved in the process. There are also a number of cases where previously unknown odontomes were detected, which modified the treatment plan or surgical approaches significantly. One such case is seen in [Figure 3](#), where

Figure 2 Images retrieved from a CBCT examination demonstrating a nasopalatine cyst, which was previously thought to be periapical disease associated with an upper central incisor.

Figure 3 CBCT slices visualising an unerupted canine with a small odontome situated buccally which was not seen on the upper standard occlusal radiograph. The outlook on managing this case changed once the odontome was identified, as it seemed less likely to require orthodontic traction once the anomaly was removed.

CBCT reveals an odontome impeding the eruption of an upper permanent canine. By reducing the risk of treatment errors, patient outcomes have been optimised remarkably by using CBCT in this study.

The authors acknowledge that the SEDENTEXCT guidelines may not cover all possible appropriate indications for making CBCT examinations and this is a limitation to this study. However, in the two cases found to be non-compliant with SEDENTEXCT, CBCT did not add any new clinical information and did not affect treatments, diagnoses or patient management. Therefore, the present study supports the current application of SEDENTEXCT guidelines to aid CBCT justification.

Conclusions

- The improved outcome in the second audit cycle is testament to the importance of regular staff training in CBCT referrals in paediatric dentistry.
- The judicious use of CBCT can significantly change the diagnoses and opinions on tooth restorability in clinical scenarios seen commonly in paediatric dentistry, such as dental trauma and pathology associated with developmental anomalies.

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