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Review Article

Paediatric magnetic resonance imaging adaptations without the use of sedation or anaesthesia: A narrative review

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ABSTRACT

Magnetic Resonance Imaging (MRI) produces images with high soft tissue contrast without the use of ionising radiation, making it a valuable tool for scanning paediatrics. However, it can be difficult to scan children when they are awake, resulting often in poor image quality scans and necessitating the use of sedation and general anaesthesia (GA). The aim of sedation and anaesthesia is to reduce anxiety and movement during image acquisition, thereby improving compliance and image quality. However, there are adverse risks and costs to their use, leading to the need to consider alternative imaging adaptation methods. This research discussed potential methods of reducing anxiety and improving paediatric compliance during MRI examinations, by assessing their feasibility for use in the clinical setting. The literature suggests that adaption strategies and modification of radiographer techniques were mostly effective in reducing the requirement of sedation/GA.

RÉSUMÉ

L'imagerie par résonance magnétique (IRM) produit des images avec un contraste élevé des tissus mous sans utiliser de rayonnements ionisants, ce qui en fait un outil précieux pour les examens pédiatriques. Cependant, il peut être difficile de scanner les enfants lorsqu'ils sont éveillés, ce qui donne souvent des images de mauvaise qualité et nécessite le recours à la sédation et à l'anesthésie générale (AG). L'objectif de la sédation et de l'anesthésie est de réduire l'anxiété et les mouvements pendant l'acquisition des images, améliorant ainsi la compliance et la qualité des images. Cependant, leur utilisation comporte des risques et des coûts négatifs, ce qui conduit à envisager d'autres méthodes d'adaptation de l'imagerie. Cette recherche a examiné les méthodes potentielles de réduction de l'anxiété et d'amélioration de la compliance pédiatrique pendant les examens IRM, en évaluant la faisabilité de leur utilisation dans le cadre clinique. La littérature suggère que les stratégies d'adaptation et la modification des techniques des radiographes étaient surtout efficaces pour réduire le besoin de sédation/AG.

Keywords: Paediatric; Magnetic Resonance Imaging (MRI); Compliance; Adaptations

Introduction

Magnetic Resonance Imaging (MRI) is increasingly becoming the modality of choice for the paediatric population. MRI produces images with superior soft-tissue resolution [1] and is able to identify and characterise pathologies [2] without the use of ionising radiation compared to other imaging modalities such as Computed Tomography (CT) [3].

Paediatric MRI is commonly used for a number of different procedures, which include imaging of the skeletal system to assess sports injuries, developmental joint abnormalities and childhood bone cancers. Brain and spinal procedures are used to diagnose pathologies such as tumours, congenital abnormalities and spinal cord conditions [4]. Abdominal and pelvic imaging is also utilised to assess pancreaticobiliary diseases such as choledocholithiasis, absent gallbladder, pancreas

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divisum [5] and inflammatory bowel disease [6]. Statistics from the National Health Service's (NHS) annual imaging datasets show a 35.4% increase of children aged 0–14 years undergoing an MRI scan from 2014 [7] to 2020 [8].

However, there are several challenges and limitations to undertaking paediatric MRI examinations. MRI scanning can be difficult for children due to the anxiety caused by the confined space, loud noises, the unfamiliar environment [9] and the requirement to remain motionless during the long acquisition times [10]. Movement during the scan may lead to non-diagnostic images due to the presence of motion artefacts, which will increase the need for prolonged or repeated examinations to ensure the required images are acquired to assist diagnosis or treatment.

Often, strategies such as sedation or general anaesthesia (GA) may be used to achieve diagnostic quality images [3]. Sedation is the depression of awareness, which can range from minimal to deep, whereas GA is a complete loss of consciousness [11]. The American Academy of Pediatrics (AAP) defines the goals of paediatric sedation as follows: to guard their safety and welfare; to minimise physical discomfort; to control anxiety and to control behaviour and/or movement to allow for the safe completion of the procedure [12].

However, the use of sedation/GA does not come without risks to the service user. Risks during the procedure may include acute adverse events, such as respiratory depression, airway obstruction, bronchospasm, hypotension, and untoward reactions to any of the medications used, such as anaphylaxis or malignant hyperthermia, nausea, and vomiting [12,13].

Incorrect administration of sedation can often pose other challenges. There is the potential of under-sedation, resulting in the patient moving, leading to the termination of the procedure. In comparison, over-sedation poses more concerning risks such as loss of airway maintenance and respiratory depression, which requires further intervention [2].

In addition, studies have documented that post-sedation or GA, service users reported to have suffered from agitation, drowsiness, nausea, gastrointestinal effects, sleep disturbances and motor imbalances [2]. Furthermore, there is evidence suggesting that the use of sedation/GA in paediatric care can have long-term neurocognitive side effects, in addition to the short-term procedure-related risks [14]. The hospital visit duration for children having MRI under sedation/GA are approximately twice that of awake patients [15,16]. Consequently, due to these factors most parents have shown interest in their children having an MRI scan without sedation/GA [2,15,17].

In addition to potential health risks, the use of sedation/GA has an impact on workflows and cost due to the increased usage of hospital resources as a specialist paediatric anaesthetic team are required in the provision of this service [12]. Cost-related factors that need to be considered include ensuring MRI compatible monitoring equipment, hospital day beds and high-cost medications are all available at the time of the procedure [2]. Furthermore, the events of failed sedation may result in a distressed child which can have negative effects for the patient, their family and the institution [18,19].

The objectives of this article are to:

- Explore the current methods used to reduce anxiety and movement during a paediatric MRI scan
- Evaluate a range of strategies that can be utilised to prepare and manage paediatric patients undergoing a MRI scan
- Recommend potential alternative techniques for use in practice by MRI radiographers when undertaking paediatric examinations.

Method

This study was conducted in the form of a narrative literature review. This method of review allows for the discovery of new types of adaptations [20] which may be available through the comprehensive, critical and objective analysis of the current medical literature published on a chosen topic [21].

A literature search for primary articles was conducted using electronic databases Google Scholar, PubMed, Ebscohost, Science Direct, ProQuest, CINAHL and Medline. These online databases were used because they provided a variety of primary sources from established, high quality and peer-reviewed journals. Database searching reduces selection bias as it ensures that relevant studies are not missed, making the search strategy reproducible [22]. Table 1 in the appendix outlines the keywords, inclusion and exclusion criteria applied during the search process to identify the most relevant papers for the review.

The use of Boolean operators 'OR' & 'AND' optimised the search by defining how the databases should combine each search term together, this ensured all possible alternative words were used to search for relevant studies. Once all possible primary studies to appraise were identified, they were then screened for relevance by checking the titles and abstracts [22].

Results

The searches returned 21 primary research studies that matched the selection criteria. All papers selected were focused on the preparation of paediatric patients for MRI without the use of sedation/GA, or provided further evidence for appropriate technique modification. The chosen articles were then categorised into the following themes by looking at patterns in the literature; natural sleep facilitation, distraction, education and radiographic technique modification. The included articles and the alternative methods to sedation/GA are presented in Table 2 in the appendix in order of respective target age ranges. The findings from the studies are discussed below.

Discussion

In the following sections, the different techniques will be described and discussed in relation to their strengths and weaknesses in order of increasing target age range as summarised in Table 2 in the appendix.

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Sleep facilitation

In the infant population, studies [23-28] concerning the replication of a child's normal feeding and sleeping pattern have shown to be successful alternatives to sedation/GA, two of which are described below.

Feed and wrap

One approach which is frequently used in current practice is the 'feed and wrap' technique, also termed 'feed and swaddle' which is where food, comfort, and warmth are used to induce natural sleep, and swaddling is used to reduce motion artefacts [23].

A number of studies [23-26,29] have reported success rates with this approach and acquired images of sufficient quality without challenges in patient preparation. A high rate of success has been seen in infants younger than six months [24,25]; furthermore, infants under three months fell asleep more easily/readily and were less likely to wake up during the study [24]. There is, however, a potential concern of longer scan duration with the feed and wrap technique due to the preparation and possibility of the child waking up during the scan . Nonetheless, studies have shown that imaging times are slightly longer in patients undergoing anaesthesia compared to feed and wrap [25] and that there is a reduction in cost and resource allocation with this technique [24,25]. This explains an increasing trend towards the use of feed and wrap over sedation/GA, where complications or side effects may be more common [13]. Overall, feed and wrap has proven to be a successful and safe technique. This is supported by the Royal College of Radiologists (RCR) [19] guidelines suggesting that infants younger than four months can successfully complete diagnostic imaging procedures with this technique.

Use of melatonin

Another non-pharmacological approach is the use of melatonin, a natural sleep cycle regulator that can induce sleep in children [27] due to its mild sedative and hypnotic effect [28]. Pasini et al. [27] used 10 mg of melatonin added to a milk drink prior to the MRI in preschool children. This achieved adequate levels of sedation, allowing successful completion of the MRI scan in 14/15 patients. A recent retrospective study evaluated the efficacy of melatonin in 64 infants and young children in neuro-paediatric MRI. They found that 77% of scans were rated diagnostically acceptable by a paediatric neuroradiologist. However, only 22% of scans were free of movement artefacts in any sequence [28]. The increased success rates may be due to the sedative effect of melatonin rather than a sleep-inducing effect. Melatonin is a much safer option than sedation/GA as no studies reported adverse events or side effects [27,28]. Furthermore, it can be used in conjunction with the feed and wrap approach, if the infant wakes up during the scan as it is cost-effective, efficacious and can be administered in follow-up MRI scans, if required.

Fig. 1. Images depicting the use of film played on a screen within the scanning room [Image shared with permission, GOSH].

Distraction techniques

Distraction can be successfully used to alleviate anxiety and minimise movement when children are inside the MRI scanner in place of physical restraint techniques [30].

MRI-compatible on MRI integrated audio-visual system

Movies can be played in the MRI scanner as depicted in Fig. 1 to occupy and entertain paediatric patients, allowing them to tolerate long scans. A study by Greene et al. [31] found that during functional MRI (fMRI) scans, head motion was significantly reduced when children viewed a cartoon movie clip compared to fixating on a cross (i.e. rest). However, these results were dependant upon age as children older than 10 years showed no significant benefit. Furthermore, the participants were a sample group of healthy individuals, so are not fully representative of the population of children who require imaging, reducing the external validity of this research. Although they found that the viewing of movies may alter fMRI data, it is still a reliable solution to reduce head motion for structural brain MRI scans [31]. The scarce attention that has been devoted to this adaptation makes it difficult to determine the effectiveness of the approach. However, the results from this study [31] propose that age-appropriate movies for patients under 10 years should be available in MRI departments that scan paediatrics.

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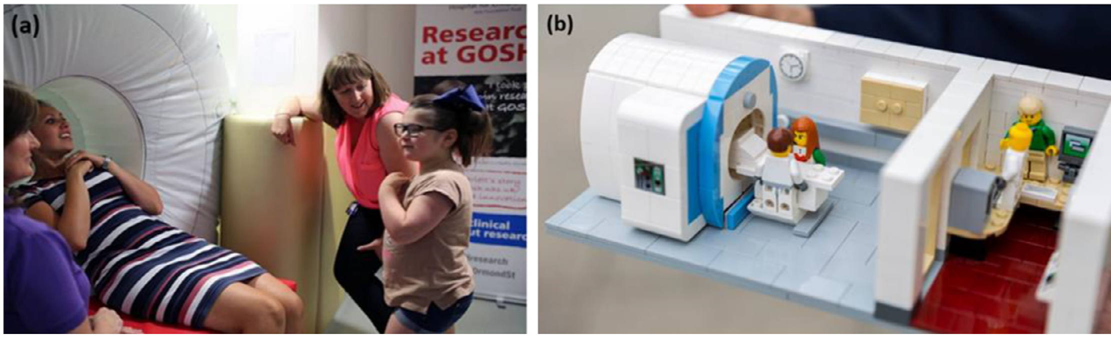

Fig. 2. Images depicting alternative play therapy methods: (a) a child being shown an inflatable MRI scanner to prepare for a scan, (b) a lego-scale version of an MRI scanner and control room [Images shared with permission, GOSH].

It is a cheap and safe method, which could potentially reduce the unnecessary sedation of young children [2].

Educational techniques

There are many preparatory methods that can educate paediatric patients in an interactive way and increase cooperation for the MRI examination.

Play therapy

Play therapy is another commonly used technique in current practice and includes familiarising the child with a model MRI machine, as shown in Figs. 2a and 2b, prior to the scan. This is often facilitated by educational play therapists and/or specially trained paediatric radiographers. This practice session allows the child to be better prepared for the actual imaging procedure [32-35].

Morel et al. [32] found that a teddy-bear model of a mock MRI scanner was an efficient tool to decrease anxiety and motion artefacts in children aged four-sixteen years. Studies [33,34] have also reported a reduction in the need for sedation with the use of play therapy in young children. In a recent retrospective study [33], it was proven to be most beneficial for children aged four-nine years as there was found to be a decrease of cases needing to be sedated from 64% to 55% as a result of this adaptation. It must be noted that this study [33] also included the use of animated videos within the training, which means it was hard to conclude whether the reduction in sedation was due solely to the effects of the model MRI or also due to the added distraction. Evidence [32-34] suggests that play-based therapy can help young children overcome anxiety and cope with the challenges related to the imaging procedure without resorting to sedation/GA. Furthermore, play-based therapy may also reduce costs in the long run for both the hospital [35] and parents [34]. This is because expensive medications and equipment are not required, and the participants are not being admitted into the hospital for recovery after sedation or GA. This also may reduce the costs for parents, including parking and accommodation during their children's hospital stay. However, play therapy usually requires a lot of planning and individual customisation to every child, therefore it limits its use to scheduled examinations. Another factor that healthcare providers must consider is the cost of employing a play therapist and ensuring their availability for the play therapy session.

Preparatory video before scan

An educational animation shown before the scan may be effective in reducing distress and can convey a positive attitude for paediatric MRI. Szeszak et al. [36] designed a short-animated cartoon-based film following the central hero's experience of MRI and recorded 24 participants aged between five to eleven years as they viewed it. They found that the animation improved knowledge, reduced anxiety, retained attention and provided coping strategies for the children. The overall aim of this study was to give the participants not only the opportunity to relate to the character shown, but also mirror them in relation to the MRI examination. This adaptation allowed the children to better understand the concept of the MRI procedure without providing complicated medical jargon, enabling them to feel in control of the situation, and provided them with the opportunity to ask questions before the scan. The videos utilised in this study [37] are readily available online which can be accessed at home or during the visit to the department. However these films are in English only, which means they are currently limited by their use to English-speaking children and their families. Future translations can allow its use for a wider non-English speaking audience.

A similar study by Rothman et al. [38] demonstrated that participants cooperated better after full instruction was offered (reading an informational booklet, watching an educational video and experiencing simulator practice) as opposed to partial instruction (only reading the informational booklet). The study revealed compliance at 47% with full instruction compared to only 30% with partial instruction. The evidence [9,39] suggests that the type of preparatory animation used is important as it must be age appropriate for success. A correlation analysis by McGlashan et al. [9] revealed a strong negative relationship between age and impact of their animation on preparation, indicating higher impact ratings for younger children.

Animated videos are inexpensive to create and easily accessible because videos can be made available over the internet and other affordable platforms for children and their parents [36,39]. Therefore, age-specific virtual education can be used as a method to increase compliance for paediatric MRI scans.

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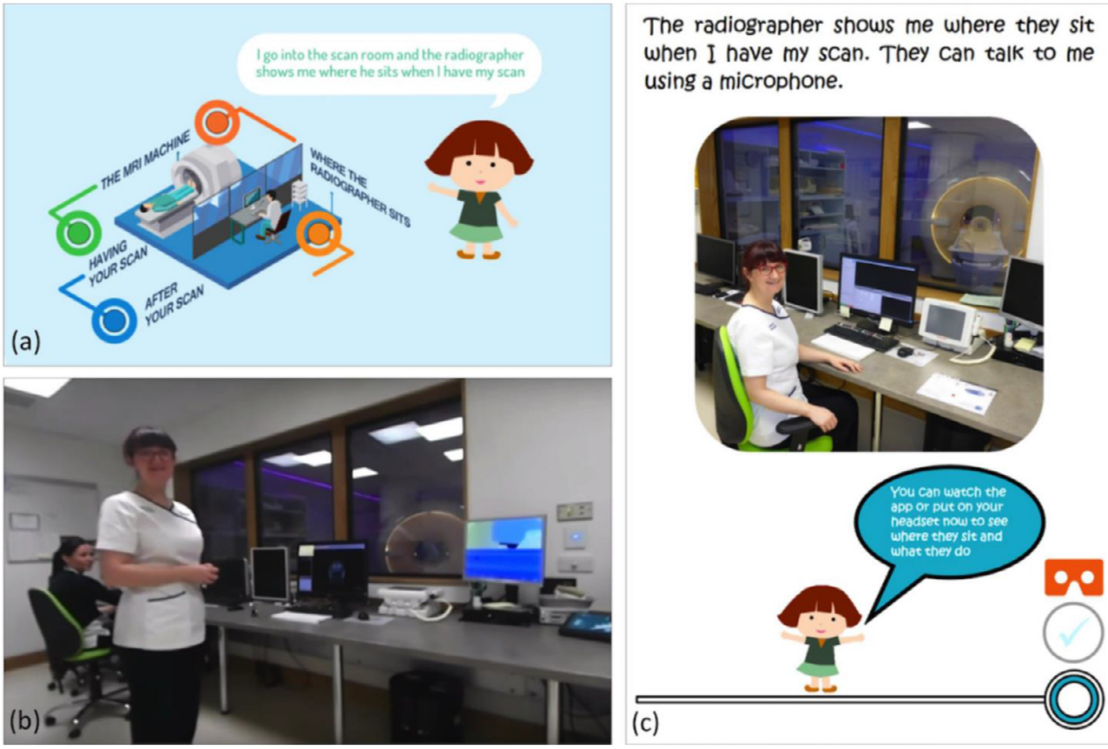

Fig. 3. Screenshots taken from a part of the virtual-reality MRI resource: (a) the app cartoon interface, (b) corresponding 360-degree video, (c) corresponding page from the preparation book.

Virtual reality (VR) MRI

VR MRI allows patients to experience what it is like to have an MRI before their upcoming appointment. Ashmore et al. [40] developed a VR resource consisting of an application with a series of panoramic 360-degrees videos of the entire MRI journey which can be viewed using an inexpensive cardboard headset (see Fig. 3).

This VR resource relieved anxiety in four to twelve-year olds and a successful awake MRI was achieved in four out of five children for whom routine care would have resulted in an MRI under GA. This resource is freely available to download and can be used by any institution scanning children [40]. Further research is needed on the use of VR in children to establish its safe or efficient use. There are potential concerns including the feelings of nausea that may be experienced by the viewer due to the acceleration in the VR environment and the user being blinded to their actual physical environment [40], so it is essential that these are always used under adult supervision to avoid accidents at home.

Radiographic technique modification

Radiographers have a key responsibility and central role before, throughout and after the scan to enhance patient safety and their experience and that of their carers.

Communication and patient preparation

Radiographers must build a trusting relationship by ensuring effective communication with their patients and their carers for a smooth and effective examination. The radiographer should always introduce themselves to the child and their family using a positive tone and directly address the child when speaking. This ensures the child feels safe and valued in the unfamiliar and often too medicalised environment of an MRI suite staffed by strangers. The radiographer is required to give clear instructions on the importance of staying still during the scan and explain the scanning procedure using simple, non-technical, child-friendly or child-adjusted language to prevent anxiety and ensure patient compliance. It is vital that this communication also suits and involves the accompanying family member/carer [41]. After the explanation, the radiographer should give the child an opportunity to discuss any concerns or worries they may have and address them before the scan.

Kada et al. [42] discovered two factors which ensure cooperation from a child during an MRI scan; these included '(a) clinicians' ability to interact intelligibly with both child and parents and (b) their capacity to tailor a child-relevant collaborative effort with each MRI.'

The patient's preparation for the scan is very important to put patients at ease and minimise movement which is critical for optimal image quality during the acquisition of images. This preparation includes patient positioning with the use of adequate padding, positioning and immobilisation aids when necessary, to ensure patients feel comfortable and safe inside the scanner bore. Room temperature maintenance and the use of ear protection such as ear plugs and headphones, to reduce the effects of the MRI-related acoustic noise [41] are vital to ensure a successful MRI examination. Acoustic noise can often be

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one of the most distressing factors for patients during clinical examinations [43].

Dean et al. [29] carried out MRI scans on 220 children under four years of age, allowing participants to enter natural deep sleep at their usual sleeping times. They also reduced noise levels within the scanner with the use of sound-insulating foam inserts, headphones and modifications to imaging pulse sequences, generating diagnostic images in 97% of cases and compliance at initial scans of nearly 90%. This study revealed that adequate patient preparation can acquire optimal images and reduce the occurrence of motion artefacts.

Motion artefact reducing techniques

Artefacts such as signal loss, blurring, ghosting and unwanted signal enhancement can all be caused by subject movement, thus degrading image quality and making images non diagnostic [29,44]. Acceleration techniques can be employed by radiographers to increase imaging speed and reduce scan duration. Simply prioritising important sequences before the child becomes restless ensures the most useful diagnostic images are acquired. Physiological causes for artefacts can be addressed through the use of age specific protocols <2years, >2years, volume imaging and parallel imaging. Parallel imaging [45] and compressed sensing [46] are robust methods for accelerating the acquisition of MRI data, to help reduce total scan time and, subsequently, scan duration. A study by Zhang et al. [47] found that a fast-combined parallel imaging and compressed sensing method is feasible in the paediatric clinical setting. Both techniques use data sparsity aiming to decrease scan time without compromising image quality by motion artefacts in awake children. Motion resistant techniques, like PROPELLER, have been shown to substantially improve or eliminate motion artefacts for a number of clinical applications including brain, shoulder and cardiac imaging [48]. The latest state-of-the-art in data acquisition and reconstruction in paediatric imaging will involve a more intense use of artificial intelligence but fully optimised and validated algorithms are needed to ensure this is also clinically useful and meaningful [49,50].

Age variation

Although it would be ideal to carry out all scans without sedation/GA, there are inevitable situations when this is not achievable. To consider the paediatric population as a one can be problematic; the term encompasses neonates to adolescents with varying degrees of development and understanding. The age appropriateness will vary from child to child and it can be hard to predict how a child will react when they are inside the actual scanner. For example, studies [9,31,33] mentioned earlier revealed that the adaptations had a larger impact on younger participants in the research, while older participants may have compiled without any additional measures. This is an important consideration for future practice as it could guide the appropriate implementation of educational or entertainment resources for the most applicable age groups. Overall, for every paediatric patient, their age, development level and individual needs (such as their temperament, stress levels, pain and illnesses at the time of imaging) have to be considered in order to select and tailor the most appropriate adaptation.

Limitations

A limitation experienced whilst conducting this review was the small number of studies found due to the exclusion criteria in Table 1 in the appendix; the use of only papers written in the English Language [51] and the lack of previous research available for some of the chosen interventions. Furthermore, most studies that emerged from the literature search were retrospective studies which could be subject to selection bias and may not be representative of the general population. Therefore, there is a need for future rigorously-designed prospective trials with larger sample sizes to provide stronger evidence and allow for a true comparison between control and adaptation groups. Overall, despite the awareness of these limitations, the study presented sufficient information to adequately answer the research aim and objectives.

Implications for practice

A list of recommendations for future practice can be found on Table 3 in the appendix.

Conclusion

This narrative review explored current techniques and evaluated novel methods to reduce anxiety and increase compliance without sedation/GA in paediatric MR both in practice and scientific study. The findings of this study have revealed that there is a great deal of potential in using alternative techniques in place of sedation/GA. However, this review acknowledges that these findings are based on investigating relatively healthy children and not those with serious conditions or comorbidities. The researchers understand that in cases of seriously unwell children or those with chronic comorbidities, learning difficulties or severe developmental delay, sedation/GA still have an important role to play in ensuring safety during imaging procedures. Sedation/GA may often be used as a 'one-size-fits-all' measure to ensure compliance, whereas this work highights that children cooperate better when they feel they are considered as an individual with autonomy. This review also revealed that the age and individual needs of the patient must always be taken into account for a successful paediatric MRI examination.

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Appendices

Appendix A

Table 1
Keywords, Inclusion and Exclusion criteria used during search process.

Keywords	Initial Keywords	MRI, magnetic resonance imaging, paediatric, sedation OR general anaesthesia, adaptation OR alternative OR compliance
	Additional Keywords: Following the initial search, additional keywords were used to accommodate the different spelling approaches used in articles published in American English. Specific adaptation-based keywords were also used to narrow down the search and locate further research on the chosen adaptations.	Pediatrics, Child, Infant, Minor, Baby, Babies, Adolescent, Young Person, Cooperation, Scan success, Motion, Movement, Distraction, Preparation, Distress, Anxiety. Feed and wrap or feed and swaddle, melatonin, play therapy, movie or video, compressed sensing, parallel imaging.
Inclusion	**1. Peer-reviewed articles**	Only articles that had been peer-reviewed were selected, to remove studies that lack credibility or academic weight. It would also prevent and reduce the presence of bias or subjectivity within the data.
	2. Paediatric patients	The title and aim of this narrative review is based on paediatric patients undergoing MRI scans without sedation/GA. This includes any indication for the MRI scan and any pre-existing condition that the paediatric patient may have.
	3. Full text available	The full article must be accessible instead of solely the citation and/or abstract. This is in order to provide the reader with context.
	4. Non-sedation or non-GA use.	Studies were only eligible if they explored techniques that did not involve the use of sedation or GA during the preparation for paediatric MRI scans.
Exclusion	**1. Reviewed articles**	These will only be used for background information and are not included within the article selection for data analysis as this review is an analysis of primary data.
	2. Articles based on imaging modalities other than MRI	This literature review is based solely on MRI. Therefore, any other imaging modalities will have no relevance to the title or the aim of the review.
	3. Patients older than 18 years	The paediatric age range is commonly defined as 0–18 years of age.
	4. Articles not in the English language	In order to avoid any misinterpretation issues, only English written literature was used. Although this will increase language bias by disregarding any important studies of other languages, the researchers did not have the resources or time to carry out a translation of other studies.
	5. Articles published before 2012	A publication date of no earlier than 2012 was used to ensure data was kept as current and reliable as possible without restricting the data.

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Appendix B

Table 2
Alternative strategies to sedation/GA for paediatric MRI].

Technique	Adaptations	Included Studies: Author (Year/Country of origin)	Main Findings	Target Age Range
1. Natural Sleep Manipulation	Feed and Wrap	Antonov et al. (2016/USA) Shariat et al. (2014/Canada) Templeton et al. (2019/USA) Gale et al. (2012/United Kingdom)	A safe, non medicinal approach with most success in infants aged up to six months old.	0–4 years
	Melatonin	Pasini et al. (2018/Croatia) Heida et al. (2019/Netherlands)	Melatonin ingestion has promising results acting as a mild sedative, although current research into its use is limited.	
2. Distraction	MRI-compatible audio-visual system	Greene et al. (2018/USA)	An audio-visual system is a cheap and effective way that can be employed by MRI departments to distract young children during the scanning process.	4–18 years
3. Educational	Play Therapy	Morel et al. (2019/France) Cavarocchi et al. (2018/Italy) Bharti et al. (2015/India)	Play therapy has been found to be most beneficial to children aged four to nine years old. It includes the use of toy model scanners for children to play with and be taught about their appointment.	4–18 years
	Preparatory video before scan	Szeszak et al. (2016/ United Kingdom) Hogan et al. (2018/ USA) McGlashan et al. (2018/United Kingdom) Rothman et al. (2016/ Israel)	Easily accessible child-friendly videos from Youtube can be used by parents to prepare children and help them become familiar with the scanning process before their MRI appointment.	
	Virtual reality MRI	Ashmore et al. (2019/United Kingdom)	Inexpensive method of experiencing an MRI appointment by viewing a VR headset, was successful in a trial setting but more research could be undertaken.	
4. Radiographic Technique Modification	Communication and patient preparation	Malamateniou et al. (2013/United Kingdom) Kada et al. (2018/Norway)	Appropriate communication with the child will ensure a trusting relationship is formed for scan success. Adequate patient preparation such as reducing noise levels will optimise the child's experience. Scanning younger children during their natural sleep, and providing older children with a degree of autonomy during their appointment has shown some success.	All ages
	Motion artefact reducing techniques	Deshmane et al. (2012/USA) Feng et al. (2016/ USA) Zhang et al. (2013/USA) Dean et al. (2013/USA)	Acceleration techniques such as parallel imaging and compressed sensing can be used to ensure motion artefacts are reduced and diagnostic quality images are produced.	

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Appendix C

Table 3
Recommendations for practice.

Recommendation	Applications to practice
Child centred approach	There is a wealth of options to ensure a sedation/GA- free paediatric MRI scan. The use of sedation/GA should be considered as the last resort option with children presumed able to comply with MRI if they are otherwise fit and healthy. To enable this there should be further research into how to assess suitability, which could be implemented at referral with emphasis on providing a multidisciplinary approach.
Further staff training	Improved training for all staff who work alongside paediatrics to equip them with tools and strategies to enable better participation and compliance, for example, being able to provide information to different development levels. This may be of more importance to centres which do not specialise in paediatric care where such training is not as thorough.
Appointment information	Investments into the provision of timely information tailored to both parents and paediatric service users prior to an appointment could be of benefit. This could be through different informational leaflets aimed at each development level for the children to explain the procedure and advice to parents on how to best support their children, including how to access educational preparatory videos online.
Age-specific adaptation	Future research should consider the specific age group that each adaptation is most appropriate for and perform a cost analysis of each adaptation to assess the feasibility of implementation for institutions.

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