Dental treatment under general anesthesia for patients with severe disabilities

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Patients with disabilities have difficulties tolerating in-office dental treatment due to limitations relating to cooperation and/or physical problems. Therefore, they often require general anesthesia or sedation to facilitate safe treatment. When deciding on dental treatment under general anesthesia, the plan should be carefully determined because compared to general patients, patients with disabilities are more likely to experience anesthetic complications because of their underlying medical conditions and potential drug interactions. Clinicians prefer simpler and more aggressive dental treatment procedures, such as extraction, since patients with impairment have difficulty maintaining oral hygiene, resulting in a high incidence of recurrent caries or restorative failures. This study aimed to review the available literature and discuss what dentists and anesthesiologists should consider when providing dental treatment to patients with severe disability under general anesthesia.

Keywords: Dental Care for Disabled; General Anesthesia.

INTRODUCTION

Patients with mental or physical disabilities usually struggle to access dental services and have difficulties in tolerating treatment. Patients who lack cooperation and have physical or mental impairments often require sedation or general anesthesia to facilitate dental treatment [1,2]. Although sedation could be an effective and safe alternative to general anesthesia for patients with disability, sedation may be difficult in patients with severe cooperation problems, especially in terms of maintaining the airway [2,3]. For some patients with disability, any treatment process that requires them to sit still and keep their mouth open without any sudden movements is challenging [2-4]. Clinicians may prefer to perform comprehensive treatment for patients with severe impairment under general anesthesia for safety and efficacy, despite the potential risks associated with anesthesia [1]. A few studies have presented dental treatments for adult patients with severe disabilities requiring general anesthesia. This study aimed to review the available literature and discuss what dentists and anesthesiologists should consider when providing dental treatment to patients with severe disabilities under general anesthesia.

METHODS

The literature was searched using Medline, PubMed, and the Cochrane Library databases. The following terms...
Fig. 1. Study selection flowchart. GA, general anesthesia.

were used for the search: disability, special needs, impairment, intellectual disability, autism, cerebral palsy, Down syndrome, general anesthesia, dental treatment, and dental care. Among the papers published from 2000 to 2021, only literature written in English was included. Articles about dental treatment under general anesthesia were selected and the subjects were limited to patients with severe disabilities requiring general anesthesia. In total, 255 articles were found. Of these, papers relating to children or adolescents and articles that were case reports or surveys were excluded. The full text of the remaining 47 articles was reviewed and unrelated articles were excluded. A total of 21 studies were finally included in the review. A detailed overview of the data selection process is presented in Fig. 1.

The articles included are listed in Table 1. Of the 21 studies, nine were about anesthetic considerations, and the rest were focused on dental care. Anesthetic considerations included indications and risks or complications of general anesthesia, and considerations during surgery. Dental contents were mainly about the prognosis of dental treatment in patients with disabilities, the comparison of oral hygiene with others, and the dental treatment procedures during general anesthesia.

CONSIDERATIONS OF GENERAL ANESTHESIA FOR DISABILITIES

1. Indications for general anesthesia

The indications for general anesthesia for dental treatment include medically compromised patients, patients with cooperation difficulties, and patients requiring extensive dental treatment [5] (Table 2). The most common indications for general anesthesia are lack of cooperation and multiple comorbidities [6-9]. Previous studies reported that approximately 45 % of patients required general anesthesia for their dental treatment due to cooperation difficulties related to autism, dementia, intellectual disability, and other mental disabilities [1,6,10]. Patients with autistic spectrum disorder (ASD) should be evaluated individually to determine whether local anesthesia, sedation, or general anesthesia are appropriate because cooperation varies from patient to patient. Depending on their level of learning difficulty and cooperation, repetitive learning may improve cooperation to enable treatment without general anesthesia [9,11]. Patients with ASD do not have a higher anesthetic risk than others, but more teeth might be
The other indication for undergoing general anesthesia is motor dysfunctions and uncontrolled tremors, such as patients with cerebral palsy, epilepsy, Parkinson’s disease, or other brain diseases [6]. Cerebral palsy is one of the most common conditions for which dental treatment under general anesthesia is required because it is characterized by muscle paralysis, involuntary physical movements, poor coordination, muscle weakness, and extracted because of their more complex cooperation problem and poorer oral hygiene [12,13]. Therefore, it is necessary to individually determine if general anesthesia is required for patients with autism as the level of individual cooperation varies. Similarly, for patients with intellectual disability, general anesthesia is considered case-by-case based on the level of cooperation difficulties [14].

### Table 1. Descriptions of included studies

| Author (year) | Type of article | Description |
|---------------|-----------------|-------------|
| **Anesthetic Contents** |
| Boyes SG, et al. (2010) [47] | Retrospective study | Identify and quantify complications occurring with the administration of anesthesia for the dental treatment of patients with special needs |
| Hanamoto H, et al. (2016) [23] | Retrospective study | Determine which method of premedication is more effective for these patients, 0.15 mg/kg of intramuscular midazolam or 0.3mg/kg of oral midazolam |
| Higuchi H, et al. (2018) [43] | Retrospective study | Investigate whether intellectual disability affects the time taken to emerge from general anesthesia |
| Hulland S, et al. (2000) [7] | Retrospective study | Determine if any single or selected characteristics could be used as predictors in defining which individuals ought to be treated in a hospital based dental program |
| Lim SW, et al. (2018) [24] | Retrospective study | Investigate the effect of midazolam and triazolam premedication before general anesthesia in patients with difficulty in cooperation |
| Maeda S, et al. (2015) [41] | Retrospective study | Identify factors affecting emergence from general anesthesia, in which each antiepileptic drugs was included as a predictor variable |
| Ouchi K, et al. (2015) [28] | Retrospective study | Investigate the impact of the type of neurological disorder on the required propofol dose for anesthesia and the time to emerge from anesthesia a during dental treatment |
| Vargas Roman Mdel P, et al. (2003) [5] | Comparative study | Review of the most important aspects relating to general anesthesia in dental therapy |
| Yumura J, et al. (2011) [48] | Comparative study | Investigate risk factors for postoperative nausea and vomiting after day care general anesthesia in mentally challenged patients undergoing dental treatment |
| **Dental Contents** |
| Chang J, et al. (2014) [12] | Comparative study | Correlate the caries related variables of special needs patients to the incidence of new caries |
| Chang J, et al. (2014) [52] | Comparative study | Evaluated the caries risk profile of patients with severe intellectual disabilities who received dental treatment under general anesthesia |
| Chang J, et al. (2017) [58] | Observational study | Evaluate the longevity of teeth with single visit endodontic and restorative treatment under general anesthesia for special needs patients and to investigate factors associated with survive and success |
| Chung SH, et al. (2019) [62] | Retrospective study | Determine the prognostic factors of periapical healing of teeth after single visit nonsurgical endodontic treatment under general anesthesia in special needs patients |
| Ekfeldt S, et al. (2013) [69] | Prospective study | Study the medium to long term outcome of implant treatment in patients with neurologic disabilities |
| Fernandez-Feijoo J, et al. (2019) [37] | Retrospective study | Assess in patients with severe disability operated under general anesthesia whether the progressive acquisition of experience by the dental team affects the type of procedure performed and the duration of operations |
| Jockusch J, et al. (2020) [38] | Retrospective study | Highlight the need for dental treatment performed under general anesthesia for people with disabilities and the associated indications and treatment patterns |
| Jockusch J, et al. (2021) [54] | Retrospective study | Analyze the treatment needs of patients who had received dental treatment under general anesthesia and the effectiveness of the treatment provided |
| Kim IH, et al. (2017) [65] | Retrospective study | Investigate outcomes following dental implantation in patients with special needs who required general anesthesia to enable treatment |
| Kovacic I, et al. (2012) [47] | Retrospective study | Determine the characteristics of comprehensive dental care in intellectual disability persons under general anesthesia, and to determine whether any changes have occurred in dental procedures during 25 years. |
| Maes MS, et al. (2021) [63] | Retrospective study | Assess the survival of direct composite restorations placed under general anesthesia in adult patients with intellectual and/or physical disabilities |
| Schnabl D, et al. (2019) [53] | Retrospective study | Assessment of demand for restorative therapy and tooth extractions under general anesthesia in adults with intellectual and/or physical disablement or psychiatric disorders with inherent dentist phobia |
other motor dysfunctions [15]. Unlike patients with lack of cooperation, patients with cerebral palsy, who may be able to communicate and control their behaviors, have involuntary movements that can lead to emergencies during treatment. Since motor disorders vary, different methods of sedation, alone or in combination, may be used to facilitate dental treatment depending on the patient’s physical condition, treatment needs, and duration of the operation [16]. Therefore, patients with brain lesions or skeletal disorders may be indicated for dental treatment under general anesthesia depending on their physical condition and the type of dental treatment required.

2. Preoperative evaluation

The American Society of Anesthesiologists (ASA) physical status classification is most commonly used as a guideline for pre-anesthesia assessment [17]. For patients classified as ASA 1 and 2, anesthesia can be safely performed [18]. However, for patients with disabilities, evaluation before anesthesia may be difficult. Although a basic preoperative evaluation using blood tests cannot be performed, blood tests are often performed under anesthesia [19,20]. Since thorough medical examinations are difficult, the patient’s past medical history, previous anesthetic exposures, allergies, and drug use before the operation should be discussed with the parents/caregivers [20] (Table 3). In Haywood’s study, most patients with disabilities who required general anesthesia were ASA grade I and II, but patients who were classified as ASA grade III and IV were 21% and 3%, respectively [20]. For patients classified as ASA 3 and 4, a medical consultation must be performed if dental treatment under general anesthesia is planned [6]. In addition, according to Wong’s study, dental treatment under general anesthesia is not recommended for patients with ASA V [6] (Table 4).

3. Premedication

Premedication via oral benzodiazepines is commonly used. Premedication is often indicated for patients who are uncooperative to calm their anxious behaviors and facilitate anesthesia induction, such as wearing a facial mask for inhalation sedation or cannulation for intravenous sedation (Table 5) [10]. The use of benzodiazepines may affect intraoperative anesthetic requirements, postoperative complications, and behavior recovery, resulting in significantly longer recovery time and complicating the postoperative psychological and pain recovery processes [11,21,22].

A study on the effectiveness of different administrative routes of midazolam suggests that oral midazolam is more commonly recommended than intramuscular injection for patients with intellectual disability [23]. Furthermore, a study comparing the patients changing cooperative levels after receiving two different types of oral premedication, midazolam, and triazolam, concluded that the effects of

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**Table 2. Indications of general anesthesia undergoing dental treatments**

| Cooperative problems |
|----------------------|
| Autism               |
| Intellectual impairment |
| Dementia             |
| Panic disorder       |

| Motor dysfunction |
|-------------------|
| Cerebral palsy    |
| Epilepsy          |
| Parkinson’s disease |
| Other brain diseases |
| Skeletal muscle disorders |

| Craniofacial abnormalities |
|---------------------------|
| Down syndrome             |
| Other genetic syndromes   |

**Table 3. Parameters for preoperative evaluation**

| Anesthetic preoperative evaluation |
|-----------------------------------|
| Past medical history              |
| Taking medication                 |
| Allergies                         |
| Previous anesthetic exposure      |
| Blood test                        |
| Chest x-ray                       |
| EKG                               |

| Dental Preoperative assessment |
|--------------------------------|
| Duration of operation          |
| Type of treatment procedure    |
| Number of appointments         |

EKG, electrocardiogram.
The risk of anesthesia complications significantly increases in patients with Down syndrome compared to other patients because of their characteristic anatomical features [30,31]. These characteristic facial features include microbrachycephaly, flat nasal bridge, short neck, protruding and large tongue, large tonsils and adenoids, narrow subglottis, and prolapsed epiglottis. Nearly 50 % of patients with Down syndrome have upper respiratory obstruction. These characteristic craniofacial anomalies increase the prevalence of perioperative airway obstruction and post-intubation stridor [30,32]. Moreover, since nasal intubation is usually preferred for dental procedures, it is more difficult for patients with abnormal anatomical structures to secure the airway [20]. Congenital heart diseases may also lead to other complications such as pulmonary hypertension.

The interaction between some medications and anesthetics affects the perioperative period. The propofol dose required for patients who use antiepileptic drugs is more than that in patients who are not taking medication [28]. Moreover, patients receiving monoamine oxidase inhibitors (MAO) or selective serotonin reuptake inhibitors (SSRIs) have a higher risk of hypo/hypertension and coma after general anesthesia [29].
Table 5. Anesthetic considerations

| Preoperative period | Intraoperative period | Postoperative period |
|---------------------|-----------------------|----------------------|
| Use of premedication| Difficulty of airway maintenance | Airway maintenance |
|                     | Excessive secretion    | Risk of aspiration (epistaxis, secretion, vomiting) |
|                     | Risk of aspiration     | Delayed emerge time   |
|                     | Endotracheal intubation| Emergence delirium    |
|                     | Vital sign maintenance | Assesment of pain     |
|                     | Hypotension            |                      |
|                     | Bradycardia            |                      |
|                     | Pulmonary hypertension |                      |
|                     | Duration of operation  |                      |
|                     | Type of treatment      |                      |

Table 6. Prognosis of dental treatments in patients with disabilities

| Author (year) | Description | No. of patients | No. of teeth | F/U period | Survival rate |
|---------------|-------------|-----------------|--------------|------------|---------------|
| Chang J, et al. (2017) [58] | Endodontic treatments | 203 | 381 | 6-81 mths | 92.5% |
| Chung SH, et al. (2019) [62] | Endodontic treatments | 241 | 448 | > 1 yrs | 97.4% |
| Ekfeldt A, et al. (2013) [69] | Implant prosthetic treatments | 27 | 88 | 10 yrs | 85.8% |
| Kim IH, et al. (2017) [65] | Implant prosthetic treatments | 19 | 73 | 15-116 mths | 94.9% |
| Maes MS, et al. (2021) [63] | Restorative treatments | 101 | 728 | 5 yrs | 67.7% |

For patients with cerebral palsy, airway management may also be difficult due to excessive secretions and the risk of aspiration during anesthesia as a result of gastroesophageal reflux which commonly occurs [34,35]. These patients also have a higher risk of hypoxia during unconsciousness [29]. Furthermore, approximately 30% of patients with cerebral palsy also have epilepsy, which must also be considered before dental treatment under general anesthesia [35]. For patients with skeletal muscle problems, such as myasthenia gravis, respiratory management is required during and after anesthesia [18].

Since the operative time is affected by anesthesia complications, preoperative dental assessment is necessary to reduce the time of treatment [36,37]. However, evaluating the dental condition is difficult and challenging in patients with severe disability, even taking radiographic images is not easy. Often, clinicians examine the patient’s oral condition, diagnose, and treatment plan at the time of general anesthesia. The duration of treatment is affected by the type of dental procedures required and not the medical conditions [37]. In Jockusch’s study, the median duration of the first general anesthesia was 180 min and decreased, as the number of general anesthesia sessions was repeated [38]. In another study, the average operative time was approximately 115 min [10]. More aggressive treatment, such as extraction, tends to be performed but this depends on the level of cooperation difficulties [39,40]. The awakening time may be longer to obtain adequate hemostasis, and it is important to control perioperative bleeding for postoperative recovery (Table 5) [41].

At least two general anesthetics are required for prosthetic treatment, but no studies have reported on the limitation of the number of anesthetics or the recommended interval between anesthesia. Therefore, it is necessary to carefully determine the type and sequence of treatment procedures for comprehensive oral management and to closely communicate with anesthesiologists to reduce the number of general anesthesia and the potential complications.

5. Postoperative management

Antiepileptic drugs cause an extended emergence time from anesthesia [28,35,42]. Even during preoperative fasting, antiepileptics should be administered to reduce perioperative or postoperative seizures [6]. In Higuchi’s study, the emergence time in patients with intellectual disability was significantly longer compared with patients
without intellectual disability. Moreover, a lower bi-spectral index was observed and a smaller amount of propofol and remifentanil was required [43]. This prolonged emergence time from anesthesia is correlated with cholinergic dysfunction in patients with mental impairment [43-45].

In addition, structural disorders of the central nervous system can cause drowsiness during the postoperative period. For example, patients with Parkinson’s disease tend to experience postoperative confusion and hallucinations, as inhaled anesthesia affects the concentration of dopamine in the brain, increasing the extracellular concentration and releasing dopamine by inhibiting reuptake in the synapses [29,46].

Ambulatory anesthesia may delay emergency care if complications or side effects of anesthesia occur after returning home, since there is no opportunity to monitor the patient’s postoperative conditions in the hospital. Therefore, it is important to meticulously monitor the patient during recovery. In particular, patients with disabilities usually have a longer emergence time and greater difficulties in maintaining the airway due to their medical conditions and medications.

6. Complications

Boynes asserted that the prevalence of complications is not significantly different among different types of anesthesia and that complications occur in approximately 20 % to 30 % [47]. The risk of anesthetic complications is dependent on the patient’s ASA classification, medical condition, type of anesthetic administration, and type of surgical procedures [47]. The complications may be mild. Approximately 4.2 % of cases are associated with moderate complications such as hypotension. Airway obstruction is the most common complication, followed by nausea and vomiting [34,47]. In Yumura’s study, the incidence of postoperative nausea and vomiting in patients with intellectual disability was 5.6%, which is higher than that in the general population [48].

Some reports have suggested that more complications occur in patients with disabilities. Lim claimed that 44.4 % of patients with cerebral palsy have complications due to difficult airway management. Complications occurred in 30.4 % of patients with ASD, 29.2% of patients with Down syndrome, and 17.1% with intellectual disability [17]. Despite these complications, general anesthesia for patients with disabilities can be performed safely and successfully [49].

CONSIDERATION OF DENTAL TREATMENT UNDER GENERAL ANESTHESIA

1. Types of dental treatment

Patients with special needs have a higher prevalence of oral diseases, especially dental caries, and it is much more difficult to maintain their oral hygiene compared with other patients [1,34,50-52]. Some studies have reported that oral hygiene is poorer in patients with psychiatric disorders than in adults with intellectual and/or physical impairments [53,54]. The reason may be related to poorer oral hygiene in the more uncooperative patients [12]. As there is a higher risk of restorative failure, dentists tend to select more aggressive treatment [55]. Clinicians may also prefer to manage the patient with less complicated procedures to prevent treatment complications or failure [1,56].

The most common dental treatment procedure carried out in general anesthesia is extraction, rather than more time-consuming or complicated treatment options such as root canal treatments [37,38,56]. In Jockush’s study, root canal treatment was performed in only 2.2% of teeth [38]. Recently, the number of extractions has reduced, as dentists prefer to undertake more operative treatment [37,57].

2. Endodontic treatment

Endodontic treatment is often performed on a single day to reduce the number of ambulatory general anesthesia. In Chang’s study, at the end of the observation period, 92.5% of single-visit endodontically treated teeth survived [58]. Although it is still difficult to determine
the treatment outcome of teeth with apical lesions requiring endodontic intervention. Previous studies have reported that the outcome of a single-visit endodontic treatment is not significantly different from the outcome of a multiple-visit endodontic treatment [59-61]. In Chung’s study, 81.5% of endodontically treated teeth with periapical lesions healed completely, while only 2.6% of the teeth showed no reduction in the size of the lesions [62] (Table 6).

3. Restorative and prosthetic treatment

Meas reported that 32.3% of restorations require extraction or replacement during the 5-year follow-up [63] (Table 6). This is a higher failure rate than the general population. However, it is still an acceptable and favorable longevity. To choose prosthetic treatment, it is necessary to consider several factors, such as material strength, the degree of wear of the opposing tooth structures, and a proper appliance design to prevent recurrent caries and facilitate cleansing [64]. Due to good marginal fitness, less wear of the opposing tooth structure, sufficient material strength, and minimal tooth structure, gold is the most predictable material for patients with disabilities [64].

Since more teeth are removed, removable or implant-supported prosthetic treatment may be inevitable for patients with impairments. Because appliances are challenging to adapt and manage, a removable prosthesis is more difficult than a fixed prosthesis. However, have been hesitant to providing implants to patients with disabilities. The O’Leary plaque index for patients with mental disabilities is reported to be 60% to 100%, indicating that implants are contraindicated in most cases [65]. However, previous studies have reported that there is no significant difference in the success rate of implants between patients with impairment and the general population [66-69]. In Ekfeldt’s study, the survival rate was 85.8%, which is lower than that in the general population but still an acceptable outcome [70] (Table 6). This study observed that only 14% of implants were lost even though the patients had neurologic disabilities with difficulty in maintaining their oral hygiene. Since the medical condition is not a contraindication to implants, the ability to maintain oral hygiene, rather than the underlying medical condition, determines the type of dental treatment.

4. Maintenance

Many studies have suggested that follow-up reviews for patients with disabilities are essential but research on the ideal frequency or interval of follow-up is rare [1,4]. Maurer reported that the caries prevalence is slightly significantly increased in patients with treatment intervals of more than 12 months compared to those of shorter intervals [71]. In contrast, Jockusch reported that the failures and emergencies of treated teeth were low with a 12-month follow-up interval [54]. Other authors have suggested that patients need to be followed up every 2-6 months during the postoperative period to maintain oral hygiene [72,73].

Oral health and diet education for caregivers/parents of patients with disabilities are as important as follow-up reviews. The proper use of oral hygiene instruments such as electronic toothbrushes and bite blocks can help to improve oral hygiene [64]. It is necessary to educate caregivers/parents to limit the cariogenic food and drinks that increase the risk of dental caries. Screening programs or early intervention programs for oral diseases provided by community dental clinics may improve oral hygiene, reduce the need for aggressive treatment, and increase the preservation of teeth for patients with disabilities [56,57].

CONCLUSION

General anesthesia is preferred in patients with severe disabilities who have difficulty coping with dental treatment in the dental practice. Anesthetic complications are more likely to occur because of the patient’s underlying medical conditions. Careful monitoring during the pre-, intra-, and post-operative periods is necessary
to minimize issues. Dentists should carefully plan and provide the necessary dental treatment, because the outcome of dental treatment in patients with disabilities is not always favorable. Therefore, to obtain a favorable prognosis, dentists and anesthesiologists should thoroughly evaluate each case before surgery and closely communicate during the intra- and post-operative periods.

**REFERENCES**

1. Mallineni SK, Yiu CK. Dental treatment under general anesthesia for special-needs patients: analysis of the literature. J Investig Clin Dent 2016; 7: 325-31.
2. Glassman P, Caputo A, Dougherty N, Lyons R, Messieha Z, Miller C, et al. Special Care Dentistry Association consensus statement on sedation, anesthesia, and alternative techniques for people with special needs. Spec Care Dentist 2009; 29: 17-20.
3. Manley MC, Skelly AM, Hamilton AG. Dental treatment for people with challenging behaviour: general anaesthesia or sedation? Br Dent J 2000; 188: 358-60.
4. Dougherty N. The dental patient with special needs: a review of indications for treatment under general anesthesia. Spec Care Dentist 2009; 29: 17-20.
5. Vargas Román Mdel P, Rodríguez Bermudo S, Machuca Portillo G. Dental treatment under general anesthesia: a useful procedure in the third millennium? (I). Med Oral 2003; 8: 129-35.
6. Wang YC, Lin IH, Huang CH, Fan SZ. Dental anesthesia for patients with special needs. Acta Anaesthesiol Taiwan 2012; 50: 122-5.
7. Hulland S, Sigal MJ. Hospital-based dental care for persons with disabilities: a study of patient selection criteria. Spec Care Dentist 2000; 20: 131-8.
8. Silvestre-Rangil J, Silvestre FJ, Espín-Gálvez F. Hospital dental practice in special patients. Med Oral Patol Oral Cir Bucal 2014; 19: e163-9.
9. Sacoor S. Anaesthesia and sedation for the autistic patient. SAAD Dig 2017; 33: 40-3.
10. Özkan AS, Erdoğan MA, Şanlı M, Kaçmaz O, Durmuş M, Çolak C. Retrospective evaluation of dental treatment under general anaesthesia. Turk J Anaesthesiol Reanim 2015; 43: 332-6.
11. van der Walt JH, Moran C. An audit of perioperative management of autistic children. Paediatr Anaesth 2001; 11: 401-8.
12. Chang J, Kim HY. Does caries risk assessment predict the incidence of caries for special needs patients requiring general anesthesia? Acta Odontol Scand 2014; 72: 721-8.
13. Rada RE. Treatment needs and adverse events related to dental treatment under general anesthesia for individuals with autism. Intellect Dev Disabil 2013; 51: 246-52.
14. Miyawaki T, Kohijitani A, Maeda S, Egusa M, Mori T, Higuchi H, et al. Intravenous sedation for dental patients with intellectual disability. J Intell Disabil Res 2004; 48: 764-8.
15. Kuban KC, Leviton A. Cerebral palsy. N Engl J Med 1994; 330: 188-95.
16. Santos MT, Manzano FS. Assistive stabilization based on the neurodevelopmental treatment approach for dental care in individuals with cerebral palsy. Quintessence Int 2007; 38: 681-7.
17. Lim MAWT, Borromeo GL. The use of general anesthesia to facilitate dental treatment in adult patients with special needs. J Dent Anesth Pain Med 2017; 17: 91-103.
18. Messieha Z. Risks of general anesthesia for the special needs dental patient. Spec Care Dentist 2009; 29: 21-5; quiz 67-8.
19. Limeres Posse J, Vázquez García E, Medina Henríquez J, Tomás Carmona I, Fernández Feijoo J, Díaz Dios P.
Pre-assessment of severely handicapped patients suitable of dental treatment under general anesthesia. Med Oral 2003; 8: 353-60.
20. Haywood PT, Karalliedde LD. General anesthesia for disabled patients in dental practice. Anesth Prog 1998; 45: 134-8.
21. Maurice-Szamburski A, Auquier P, Viarre-Oreal V, Cuvillon P, Carles M, Ripart J, et al. Effect of sedative premedication on patient experience after general anesthesia: a randomized clinical trial. JAMA 2015; 313: 916-25.
22. Kain ZN, Sevarino F, Pincus S, Alexander GM, Wang SM, Ayoub C, et al. Attenuation of the preoperative stress response with midazolam: effects on postoperative outcomes. Anesthesiology 2000; 93: 141-7.
23. Haramoto H, Boku A, Sugimura M, Oyamaguchi A, Inoue M, Niwa H. Premedication with midazolam in intellectually disabled dental patients: intramuscular or oral administration? a retrospective study. Med Oral Patol Oral Cir Bucal 2016; 21: e470-6.
24. Lim SW, So E, Yun HJ, Karm MH, Chang J, Lee H, et al. Analysis of the effect of oral midazolam and triazolam premedication before general anesthesia in patients with disabilities with difficulty in cooperation. J Dent Anesth Pain Med 2018; 18: 245-54.
25. Cagiran E, Eyigor C, Balcioglu T, Uyar M. Tracheal intubation in intellectually disabled patients: clinical usefulness of remifentanil and sevoflurane without a muscle relaxant. J Int Med Res 2013; 41: 1632-8.
26. Howes OD, Rogslaki M, Findon JL, Wachers RH, Charnan T, King BH, et al. Autism spectrum disorder: consensus guidelines on assessment, treatment and research from the British Association for Psychopharmacology. J Psychopharmacol 2018; 32: 3-29.
27. Apfelbaum JL, Grasela TH, Hug CC Jr, McLeskey CH, Nahrwolf ML, Reizen MF, et al. The initial clinical experience of 1819 physicians in maintaining anesthesia with propofol: characteristics associated with prolonged time to awakening. Anesth Analg 1993; 77: S10-4.
28. Ouchi K, Sugiyama K. Required propofol dose for anesthesia and time to emerge are affected by the use of antiepileptics: prospective cohort study. BMC Anesthesiol 2015; 15: 34.
29. Frost E. Differential diagnosis of delayed awakening from general anesthesia: a review. Middle East J Anaesthesiol 2014; 22: 537-48.
30. Bordin LM, Colligan J, Brandom BW. Frequency of anesthesia-related complications in children with Down syndrome under general anesthesia for noncardiac procedures. Paediatr Anaesth 2004; 14: 733-8.
31. Akpinar H. Evaluation of general anesthesia and sedation during dental treatment in patients with special needs: a retrospective study. J Dent Anesth Pain Med 2019; 19: 191-9.
32. Sedaghat AR, Flax-Goldenberg RB, Gayler BW, Capone GT, Ishman SL. A case-control comparison of lingual tonsillar size in children with and without Down syndrome. Laryngoscope 2012; 122: 1165-9.
33. Bhatta S, Verma IC, Shrivastava S. Congenital heart disease in Down syndrome: an echocardiographic study. Indian Pediatr 1992; 29: 1113-6.
34. Nolan J, Chalkiadis GA, Low J, Olesch CA, Brown TC. Anaesthesia and pain management in cerebral palsy. Anaesthesia 2000; 55: 32-41.
35. Wass CT, Warner ME, Worrell GA, Castagno JA, Howe M, Kerber KA, et al. Effect of general anesthesia in patients with cerebral palsy at the turn of the new millennium: a population-based study evaluating perioperative outcome and brief overview of anesthetic implications of this coexisting disease. J Child Neurol 2012; 27: 859-66.
36. Voytus ML. Evaluation, scheduling, and management of dental care under general anesthesia for special needs patients. Dent Clin North Am 2009; 53: 243-54, viii-ix.
37. Fernández-Feijoo J, Carro B, Branco A, Garcia-Caballero L, Diniz M, Limeres J. The effect of dentist experience on the treatment of individuals with disability under general anesthesia. Spec Care Dentist 2019; 39: 281-6.
38. Jockusch J, Sobotta BAJ, Nišchke I. Outpatient dental care for people with disabilities under general anaesthesia in Switzerland. BMC Oral Health 2020; 20: 225.
39. Mitsea AG, Karidis AG, Donia-Bakoyianni C, Spyropoulos ND. Oral health status in Greek children and teenagers,
with disabilities. J Clin Pediatr Dent 2001; 26: 111-8.
40. Schmalz G, Farack M, Kottmann T, Schmidt J, Krause F, Ziebolz D. Preoperative dental examination might prevent unnecessary tooth extractions during dental treatment of patients with disabilities under general anaesthesia - results of a retrospective cross-sectional study. Oral Health Prev Dent 2020; 18: 139-44.
41. Maeda S, Tomoyasu Y, Higuchi H, Ishii-Maruhama M, Yamane A, Yabuki A, et al. Independent factors affecting recovery time after sedation in patients with intellectual disabilities. Open Dent J 2015; 9: 146-9.
42. Maeda S, Tomoyasu Y, Higuchi H, Ishii-Maruhama M, Egusa M, Miyawaki T. Independent predictors of delay in emergence from general anesthesia. Anesth Prog 2015; 62: 8-13.
43. Higuchi H, Maeda S, Ishii-Maruhama M, Honda-Wakasugi Y, Yabuki-Kawase A, Miyawaki T. Intellectual disability is a risk factor for delayed emergence from total intravenous anaesthesia. J Intellect Disabil Res 2018; 62: 217-24.
44. Ferreira-Vieira TH, Guimaraes IM, Silva FR, Ribeiro FM. Alzheimer's disease: targeting the cholinergic system. Curr Neuropharmacol 2016; 14: 101-15.
45. Kimura R, Safari MS, Mirnajafi-Zadeh J, Kimura R, Ebina T, Yanagawa Y, et al. Curtailing effect of awakening on visual responses of cortical neurons by cholinergic activation of inhibitory circuits. J Neurosci 2014; 34: 10122-33.
46. Misal US, Joshi SA, Shaikh MM. Delayed recovery from anesthesia: a postgraduate educational review. Anesth Essays Res 2016; 10: 164-72.
47. Boynes SG, Lewis CL, Moore PA, Zovko J, Close J. Complications associated with anesthesia administered for dental treatment. Gen Dent 2010; 58: e20-5.
48. Yumura J, Nakata E, Miyata M, Ichinohe T, Kaneko Y. Risk factors for nausea and vomiting after day care general anesthesia in mentally challenged patients undergoing dental treatment. Bull Tokyo Dent Coll 2011; 52: 113-8.
49. Caputo AC. Providing deep sedation and general anesthesia for patients with special needs in the dental office-based setting. Spec Care Dentist 2009; 29: 26-30.
50. Santos MT, Biancardi M, Guare RO, Jardim JR. Caries prevalence in patients with cerebral palsy and the burden of caring for them. Spec Care Dentist 2010; 30: 206-10.
51. Stanková M, Buček A, Dostálová T, Ginzelová K, Pacáková Z, Seydlová M. Patients with special needs within treatment under general anesthesia - meta-analysis. Prague Med Rep 2011; 112: 216-25.
52. Chang J, Lee JH, Son HH, Kim HY. Caries risk profile of Korean dental patients with severe intellectual disabilities. Spec Care Dentist 2014; 34: 201-7.
53. Schnabl D, Guarda A, Guarda M, von Spreckelsen LMI, Riedmann M, Steiner R, et al. Dental treatment under general anesthesia in adults with special needs at the University Hospital of Dental Prosthetics and Restorative Dentistry of Innsbruck, Austria: a retrospective study of 12 years. Clin Oral Investig 2019; 23: 4157-62.
54. Jockusch J, Hopfenmüller W, Ettinger R, Nitschke I. Outpatient, dental care of adult vulnerable patients under general anaesthesia-a retrospective evaluation of need for treatment and dental follow-up care. Clin Oral Investig 2021; 25: 2407-17.
55. Nunn JH, Davidson G, Gordon PH, Storrs J. A retrospective review of a service to provide comprehensive dental care under general anesthesia. Spec Care Dentist 1995; 15: 97-101.
56. Lee PY, Chou MY, Chen YL, Chen LP, Wang CJ, Huang WH. Comprehensive dental treatment under general anesthesia in healthy and disabled children. Chang Gung Med J 2009; 32: 636-42.
57. Kovacić I, Tadin A, Petricević N, Mikelić B, Vidović N, Palac A, et al. Changes of the dental service delivered to patients with intellectual disability under general anaesthesia in Dental Polyclinic Split, Croatia, during the years 1985-2009. Coll Antropol 2012; 36: 785-9.
58. Chang J, Kim HY. Prognostic factors of single-visit endodontic and restorative treatment under general anaesthesia for special needs patients. J Oral Rehabil 2017; 44: 96-104.
59. Moreira MS, Anuar ASN, Tedesco TK, Dos Santos M, Mortimoto S. Endodontic treatment in single and multiple visits: an overview of systematic reviews. J Endod 2017; 43: 864-70.
60. De-Deus G, Canabarro A. Strength of recommendation for single-visit root canal treatment: grading the body of the evidence using a patient-centred approach. Int Endod J 2017; 50: 251-9.

61. Paredes-Vieyra J, Enriquez FJ. Success rate of single- versus two-visit root canal treatment of teeth with apical periodontitis: a randomized controlled trial. J Endod 2012; 38: 1164-9.

62. Chung SH, Chun KA, Kim HY, Kim YS, Chang J. Periapical healing in single-visit endodontics under general anesthesia in special needs patients. J Endod 2019; 45: 116-22.

63. Maes MS, Kanzow P, Hrasky V, Wiegaand A. Survival of direct composite restorations placed under general anesthesia in adult patients with intellectual and/or physical disabilities. Clin Oral Investig 2021.

64. Buda LV. Ensuring maintenance of oral hygiene in persons with special needs. Dent Clin North Am 2016; 60: 593-604.

65. Kim IH, Kuk TS, Park SY, Choi YS, Kim HJ, Seo KS. Prognosis following dental implant treatment under general anesthesia in patients with special needs. J Dent Anesth Pain Med 2017; 17: 205-13.

66. Smith RA, Berger R, Dodson TB. Risk factors associated with dental implants in healthy and medically compromised patients. Int J Oral Maxillofac Implants 1992; 7: 367-72.

67. Nam H, Sung KW, Kim MG, Lee K, Kwon D, Chi SI, et al. Immediate implant placement for schizophrenic patient with outpatient general anesthesia. J Dent Anesth Pain Med 2015; 15: 147-51.

68. Hong YJ, Dan JB, Kim MJ, Kim HJ, Seo KS. Prognosis after treatment with multiple dental implants under general anesthesia and sedation in a cerebral palsy patient with mental retardation: a case report. J Dent Anesth Pain Med 2017; 17: 149-55.

69. Ekfeldt A. Early experience of implant-supported prostheses in patients with neurologic disabilities. Int J Prosthodont 2005; 18: 132-8.

70. Ekfeldt A, Zellmer M, Carlsson GE. Treatment with implant-supported fixed dental prostheses in patients with congenital and acquired neurologic disabilities: a prospective study. Int J Prosthodont 2013; 26: 517-24.

71. Maurer SM, Boggs AM, Mourino AP, Farrington FH. Recall intervals: effect on treatment needs of the handicapped patient: a retrospective study. J Clin Pediatr Dent 1996; 20: 123-6.

72. Berkowitz RJ, Moss M, Billings RJ, Weinstein P. Clinical outcomes for nursing caries treated using general anesthesia. ASDC J Dent Child 1997; 64: 210-1, 228.

73. Mitchell L, Murray JJ. Management of the handicapped and the anxious child: a retrospective study of dental treatment carried out under general anaesthesia. J Paediatr Dent 1985; 1: 9-14.