FACULTY OF MEDICINE
AND HEALTH SCIENCES

The use of Er:YAG laser in comparison with the traditional handpieces for pit and fissure sealants in children from 7 to 11 years old. A comfort study

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2 Abstract

Aim: The aim of the current study is to provide information in regard to the comfort and acceptability of children when Er:YAG laser is used during the application of pit and fissure sealants compared to the traditional rotary handpieces.

Materials and Methods: 41 patients aged between 7-11 years old, who needed pit and fissure sealants on the deep fissures of two permanent molars located bilateral in the mouth and in the same jaw were selected for this study. The quadrants and the procedure to start were allocated according to the double coin technique, heads or tails, in a split mouth design to either Er:YAG laser preparation or the conventional invasive technique with a bur. All patients were selected from the Paediatric dental clinic at the University hospital of Ghent. At the end of each treatment the patient was asked to rate his experience using a revised-faces pain scale from 0 (no pain) to 10 (extremely painful) followed by the completion of a five point Likert Scale. Finally, the patient was asked to select the treatment which he or she found to be the less stressful one and the one he or she would choose in the future.

Results: The majority of the patients preferred the bur treatment according to results from both scales and also from the direct questions. There was a statistical significant difference for the revised-pain face scale ($P<0.05$) and for the Likert scale ($P<0.05$) used for the current study. It was remarquable that ‘noise’ played an enormous role in favour of the choice for the ‘bur’.

Statistics: For the statistical analysis, the Wilcoxon Signed Ranks test was used to interpret the non-parametric data using the software of SPSS 22.

Conclusions: Most of the children felt more comfortable when they were treated using the traditional handpiece with the bur. On the basis of this study, Er:YAG laser is not a realistic alternative to decrease discomfort during invasive procedures in paediatric dentistry

3 Literature review

3.1 Introduction

Currently, in the field of the paediatric dentistry there are many well developed and brand new tools trying to give the best results with the less possible discomfort. (Lukac et al., 2007). For the needs of this literature review the words 'laser in dentistry', 'pit and fissure sealants', ' Er:YAG laser' where used separately or combined with the search machines of PubMed, Google Scholar, Web of Science, SciELO and the Cochrane library. Firstly, some thousand articles appeared but when progressing to an advanced search with parameters, language in English, age of publication the last 20 years and full text availability, the results were significantly limited. Most of the articles were quite recent whilst some additional articles were used containing important information over the history and the function-safety of the laser devices as well as over the history and the use of the pit and fissure sealants. After examination and revision of the articles excluding these of low evidence (case reports, experts opinion) and these with no important content for this literature review, we came up with the final number of 62 articles. (Fig1) For the needs of the study, material was also used from the presentations of Prof Giovanni Olivi (University of Genoa) in Gent Paediatric Department the last two years.

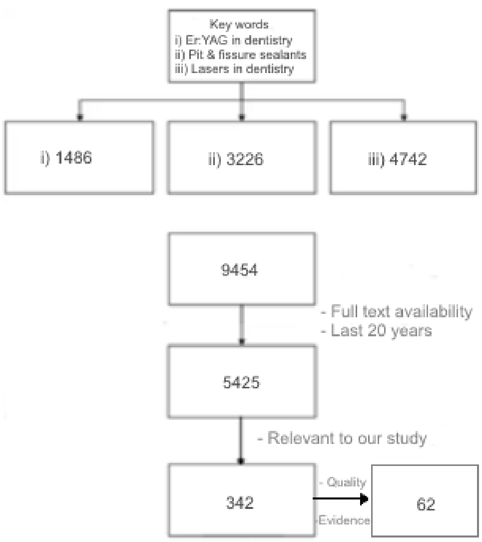


Figure 1: Flow chart for the articles collection

3.2 Pit and fissure sealants

Pit and fissure sealants were first introduced in 1960s. (Saloranta et al., 2013) It is a preventive dental measure in which a sealing material is placed on the pits and the occlusal, palatal and/ or bucal fissures of the tooth in order to keep it protected from the plaque and food particles accumulation in the area. Thus, it remains caries- free as long as the sealant is retained on its initial place.

Dental caries is still a major problem in the oral system even if it has significantly improved from the past years. Cariogenicity is a daily process in the oral cavity, being the result of the balance between mineral loss and mineral gain from the teeth. In cases that mineral loss dominates due to poor brushing, no fluoride intake, malnutrition and regular consumption of fermentable carbohydrates, the mineral integrity of the tooth is compromised and if this persists over a period of time a cavity progresses on the tooth surface. (van Loveren et al., 2016)

Preventive dental measures can be applied as a public health strategy or at an individual basis depending on the caries-risk of the population. Caries risk assessment should be an additional step in the everyday clinical practise in all the dental clinics aiming to the right determination and individual approach for every single different patient. Self-management goals should be set followed by motivational interviewing. This helps the patients and their parents to understand the cariogenic process and the possible bad habits. (van Loveren et al., 2016) There are many different ways to define the probability for someone to develop dental caries. The clinician should choose the one which fits best to him and start using it regularly in order to establish a recurrent safe way for the appropriate caries risk assessment. As a result of this, he will be able to undertake the necessary preventive and restorative treatment measures in each separate case. (Beauchamp et al., 2008)

3.2.1 Types of sealing materials

There are different types of pit and fissure sealants with the two most prevalent ones being:

- Resin based sealants

- Glass ionomer cements

    - Conventional
    - Resin Modified

In the first category, which is the most prevalent, the polymerisation of the material can be achieved by using photopolymerisation under emission of visible light, autopolymerisation or a combination of the two. Resin based sealants should be the first choice of use when this is necessary. There are different products available on the market. Some of them contain colour changes during the curing or the polymerization phase in order to make it easier for the clinician to achieve appropriate adaptation and good retention control on the follow up. Combination of resin based sealants along with fluoride are also available on the market but there are no existing studies confirming the superiority of these materials concerning the prevention of caries in comparison to the classic resin sealants (Simonsen et al., 2011).

Glass ionomer sealants are mainly characterized by their efficacy to release fluoride. These should only be used in special cases such as when the procedure needs to be really fast and when the control of the isolation is not identical. It is not yet evidence based if the containing fluoride actively protects the tooth surface from a cariogenic potential attack or from a further progression of the already existing caries lesion. The manipulation of the glass ionomer sealants is considered to be easier because no intermediate etching process is necessary for the bonding with the enamel surface. (Beauchamp et al., 2008)

3.2.2 **Indications**

As already mentioned, it is highly recommended for the clinician to follow a specific way to categorize and assess the caries risk of every individual. He or she has to use and become familiar with one method in order to perform better and safer caries risk assessment. Clinical examination, supported by radiographs when necessary, medical and social status, previous caries experience and other possible risk factors will determine the cariogenic status of the patient. (Welbury et al., 2004)

Caries reduction can be achieved when resin based sealants are placed on permanent molars of children and adolescents, compared to no sealants use, as shown in a study of Saloranta et al., (2013) with 48 months follow up. There was a significant reduction of caries from 86% after the first year of sealants placement to 78,6% after two years and 58,6% after 4 years according to the American Dental Association expert panel.

Occlusal caries on permanent first molars of children were reduced in a percentage of 76,3% after 4 years of sealant placement even though the teeth were sealed again when this was needed. In addition, 65% reduction was found after 9 years of sealant placement with no replacement when needed (Simonsen et al., 2011)

The guidelines for the use of pit and fissure sealants according to the EAPD organisation are the following:

- Teeth at increased risk for developing caries or teeth with caries limited only to the enamel
- Children medically compromised or special care patients. Pit and fissure sealants can be applied to all primary and permanent teeth trying to maintain a high oral status protecting the general health system of those patients
- High risk patients with active caries. Again primary and permanent dentition should be sealed including the bucal fissures of the molars
- Children without active caries but with deep fissures on the molars that result in high plaque accumulation (Welbury et al., 2004)

It's worth emphasizing that despite all the above mentioned clinical recommendations over the use of sealants, the most important factor affecting the success rate of them is the retention and the follow up of the patient. Caries risk assessment is not a permanent situation and it should be re-evaluated by monitoring the patients regularly in order to detect any changes in the oral habits. Partial or total sealant loss can lead to the creation or progression of already existing lesions. Last but not least, using a sealant at the best case can arrest the progression of any non cavitated lesion. On the other hand, in case of failure it can postpone the restorative treatment of the sealed teeth. (Bakhshandeh et al., 2012)

3.2.3 Technique

There are different clinical approaches on how to place pit and fissure sealants. It is quite a sensitive technique which demands to follow the necessary steps as well as the cooperation of the patient. The clinician has to choose over minimal invasive techniques where there is no drilling of the teeth or there is minimal drilling intervention with a bur or air abrasion. (Bagherian et al., 2016) Additionally, laser Er:YAG can be a fourth choice for the preparation of the enamel having also etching properties (Lawrence et al., 2004). Nevertheless, there is strong evidence over no use of air abrasion as an enameloplasty method. (Yazici et al., 2006) After the use of 37% phosphoric acid gel, it remains debatable if bonding agents should be used for adhesion.

In general, studies support the use of a bonding agent containing primer and adhesive for the pre-etched surface and the sealing material. (Beauchamp et al., 2008) In addition, another study of Sakkas et al., (2013) concluded that 4^{th} and 5^{th} generation adhesive systems give a significantly better performance compared to the 6^{th} generation bonding agents containing etching, prime and bond in a single bottle or to the normal acid etch technique without bonding placement. This finding is also in agreement with the recommendation of the American association, supporting that retention is significant lower when using bottles containing etch, prime and bond. EAPD guidelines do not support the use of bonding agents for the application of pit and fissure sealants.

Placement and light curing follows the polymerization of the resin based sealants, making sure that no bubbles are existing on the surface of the sealant. Dry conditions should be maintained on every separate step as moisture involvement can severely compromise the prognosis of the treatment. The use of cotton pellets has similar results with the use of rubber dam as shown by Lygidakis et al in 1994. Occlusion should be checked as over-placement of material can be annoying for the patient and can lead to early partial loss of the sealant. (Beauchamp et al., 2008)

3.3 Er:YAG laser in dentistry

3.3.1 History

The acronym laser, Light Amplification by Stimulated Emission of Radiation, is the name of a promising device which came into the market many decades ago in 1964. (Coluzzi 2004)

The first uses of laser concerned medical departments like dermatology, ophthalmology and general surgery. After some years, the idea that laser can be used also in the dentistry field became a reality when the first soft-tissue lasers where introduced, followed by the hard tissue laser in 1997 (Fig 2). (Verma et al., 2012)

Table 1: Common laser types used in dentistry

Laser type	Construction	Wavelength(s)	Delivery system(s)
Argon	Gas laser	488, 515 nm	Optical fiber
KTP	Solid state	532 nm	Optical fiber
Helium–neon	Gas laser	633 nm	Optical fiber
Diode	Semiconductor	635, 670, 810, 830, 980 nm	Optical fiber
Nd:YAG	Solid state	1064 nm	Optical fiber
Er, Cr:YSGG	Solid state	2780 nm	Optical fiber
Er:YAG	Solid state	2940 nm	Optical fiber, waveguide, articulated arm
CO_2	Gas laser	9600, 10600 nm	Waveguide, articulated arm

Figure 2: Laser types used in dentistry

The first time that erbium: yttrium-aluminium-garnet laser was tested was in 1988 by Paghdiwala et al, resulting in enamel and dentin ablation under low energy emission. Later studies showed that when Er:YAG laser is used under the right settings and water-spray cooling, no thermal damage on the hard tissues and the pulp can occur. Despite the fact that the first laser was constructed in Germany 1992 (Kavo Key Laser, Kaltenbach and Voigt Gmbh & Co., Biberach/Riss), the official approval from the FDA came in 1997 when Er:YAG laser could be legally used for caries removal, condition and cavity preparation without causing any thermal damage to the pulp. (Glenn van As 2004)

The question is why there is so much discussion over lasers. Local anesthesia and drilling burs have always been the main problem of the everyday dental clinical practice. Introducing an alternative technique which can provide the same results with the drilling bur, with minimal or no dose of local anesthesia, with a great elimination of any vibrations-drilling noise and a much more comfortable procedure for the patient, can surely be taken very interestingly into account. Hard tissue lasers can be used for enameloplasty, dentin cementum and caries removal, bone cutting as well as for soft tissue intervention. It is a very well promising weapon which time after time is widely more recognised and frequently used. (Glenn van As 2004)

3.3.2 Laser biophysics

When using a laser device the clinician should be aware of all the different settings available for every possible use of the machine. Additionally, he has to be well trained and familiar with it, so he or she can achieve the best result in the minimum time whilst keeping himself, the dental staff and the patient safe.

The wavelength of the laser, the energy density, the pulse duration, the spot-fiber size and the properties of radiated tissue are factors which should be carefully adjusted and taken into consideration before using any kind of laser. After interaction of a laser beam with a tissue four different reactions of the light can occur (Fig 3)

1. Transmission
2. Absorption
3. Scattering
4. Reflection

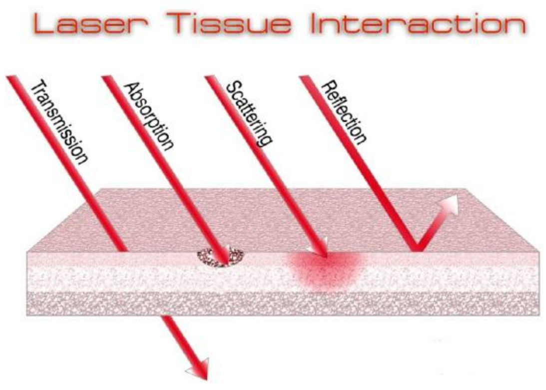


Figure 3: : Different laser tissue interaction

The Er:YAG laser as well as all the different erbium lasers have a common characteristic. They emit in wavelengths which are highly absorbed by the water, hydroxyapatite and the collagen. More specifically Er:YAG laser emits in a wavelength of 2,94 μm which is the absorption peak of the water in comparison with the Er,CR:YSGG which emits considerably lower at 2,78 μm (Fig 4). Both of these types of laser can only penetrate a few micrometers into the enamel. For instance, when using 300 microsecond pulse width, the Er:YAG laser penetration efficacy is only 5 μm. In this way very low heat can be progressed and no damage to the pulp can occur when used in combination with a water spray cooling.

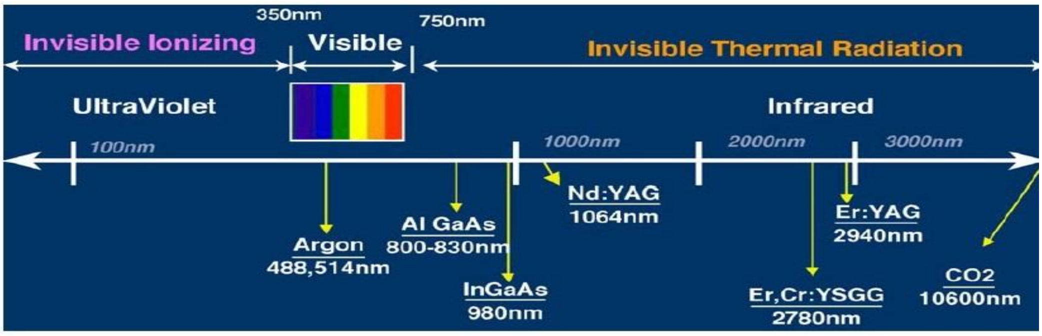


Figure 4: Electromagnetic spectrum for lasers used in dentistry (Coluzzi et al., 2004)

It is quite important to understand and analyze how the laser beam is produced. As already mentioned before, LASER is an acronym with every single word having a special meaning to its functionality. Light, when referring to the laser light, has a very special and specific property: it is monochromatic. It can be visible or invisible depending on the wavelength of emission and it has also three more specific features: Collimation, which is a beam with concrete spatial boundaries capable of maintaining a constant size and shape similar to an x ray machine. The second one is coherency, which ensures that all the light waves produced by the laser are the same. Last one is the efficiency regulating the clinical application and success of the laser beam. Amplification is a procedure occurring into the device of laser and for a better understanding of this, it is necessary to explain exactly how the laser beam is produced. The laser machine is constituted by many different parts. The main one is the optical cavity situated at the centre of the device. The core of the cavity contains all the chemicals, molecules or compounds which form the so called active medium. This is where the elements of yttrium, aluminium and garnet are placed. The active medium can be either Argon or CO_2. At the beginning and at the end of the optical cavity there are two mirrors parallel placed to each other. Around the core of the laser, is the excitation source which can be either a flashlamp or an electrical coil which offers the necessary energy to produce the stimulated emission to the active medium. Last parts of the device are the cooling system, focusing lenses and other controls completing the quite impressive laser system (Fig 5) (Verma et al.,2004)

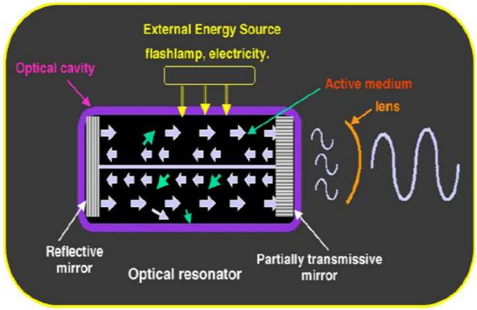


Figure 5: The basic components of a laser

Stimulated emission occurs when two identical photons are travelling in the optical cavity as a coherent wave. These photons have the ability to activate more atoms when a permanent energy supply is maintained for the excitation of the atoms. The already activated photons reflect to the mirrors in each side of the optical cavity producing more stimulated emission. Passing through the active medium, an increasing power of the photon beam creates an effect called amplification, while the parallelism of the mirrors guarantees the collimation of the light. Finally, light can exit the optical cavity because one of the two mirrors is transmissive. Radiation is the form of the electromagnetic energy produced by the laser device, resulting by the light waves which are emitted from the optical cavity. (Coluzzi 2004)

3.3.3 Laser Function

There are many different ways in which a laser beam can be delivered to the dental tissues. (van As 2004) Specifically, for the hard tissue Er:YAG lasers, the transmission of the laser light from the optical cavity to the handpiece, can be done through three different ways.

- Glass fiber optic cable (minimal hydroxyl content)
- Flexible hollow waveguide or tube
- Articulated arm

Fiber optic cable is more expensive than the hollow waveguide but it is way more flexible and longer. Articulated arms are most commonly used for even longer wavelengths like for CO_2 lasers. At the end of these delivery systems, there is a kind of high-speed or a pen similar handpiece with a sapphire or quartz ending tip which can be easily replaced. (Coluzzi 2004)

Unlike what is happening when using the conventional drilling systems, laser can be used either in contact or in contactless way with the dental tissue. In the non contact use, a laser beam is delivered in a distance of some millimetres from the targeting tissue. This requires appropriate knowledge and experience of the clinician as well as enough concentration during the procedure. If the laser beam belongs to the invisible light, a special additional aiming beam is added to the system, allowing the clinician to clearly see, know and control where the laser beam will be focused. In a close distance, the laser has more power efficacy while when defocused at a greater distance the laser beam disperse. (Coluzzi 2004)

Another characteristic of the laser settings is how the laser energy is applied to the tissues. It can be in a continuous or in a pulsed manner. In the first case, the power of the laser is maintained stable as long as the clinician presses the foot switch. While operating in a pulse manner, power is delivered with periodic interruptions reaching the peak power at regular intervals depending on the already adjusted settings. Power is given by the follow type:

$P = E/T$ and $T = 1/f$ so $P = E \times f$

(Power is the joule per second and power is counted in watt while frequency (f) is counted in hertz and energy (E) is counted in Joules)

It is important to mention that dental tissues which are under irradiation from a laser beam , need some time to recover from the thermal effect. This can be provided by manually removing the laser beam when operating in a continuous way or it can occur spontaneously in a pulsed mode of delivery as the tissues have the time to restore in between the separate pulses. Frequently, pulsed manner is the treatment of choice for soft tissue operations because it avoids a possible irreversible thermal damage while in hard tissue procedures the continuous delivery is preferable in order to ablate the highly mineralised enamel in combination always with water cooling spray, balancing the increase of the temperature.

Er:YAG laser emits in a wavelength of 2.94 μm and it is very well absorbed by water and hydroxyapatite. The function of all the laser systems is based on the photothermal effect conversing the laser light to heat. Developed tissue temperature can cause different thermal effects (Fig 6) (Coluzzi 2004)

Tissue temperature (°C)	Observed effect
37-50	Hyperthermia
60-70	Coagulation
70-80	Welding
100-150	Vaporization, ablation
>200	Carbonization

Figure 6: Target tissue effects in relation with the temperature

Ablation of the enamel occurs due to thermomechanical interaction. Water molecules lying in between the enamel prisms, are starting to be expanded provoking small explosions something which subsequently leads to the enamel excision. Water cooling spray guarantees the minimal thermal effect to the adjacent tooth structure. In parallel, Erbium lasers were proved to have also bactericidal effect. This results from the fact that bacterial cells contain also water which absorbs the laser light, ending to a catastrophe of the cell similar to what is happening during the hard tissue ablation. (Coluzzi et al., 2004)

3.3.4 Laser Safety

Using a laser machine requires many different safety measures which can ensure a secure procedure for the patient as well as for the dental staff. Three parameters should be taken into consideration when applying the laser device.

- The manufacturer instructions
- Appropriate use of the tool
- Protection of the staff and the patients

First of all, a manufacturer of a laser device should prove the safety and efficacy of the laser machine. In addition to this, a number of criteria should be met in order for the device to get an approval and be sold in the market. Characteristics like a key lock switch, laser emission indicator, remote interlock connector, safety interlocks location of controls, power display, safety shutter, manual reset system time out, laser stop button and sterilisable tips or handpieces and fibers are necessary for the proper function and approval of the device.

Laser use demands also a specific place where needful measures can be undertaken. Written policies of the procedure and the possible hazards should be available. Furthermore, a sign that a laser is used should be clear and easily seen by people in the surrounding area.

It is commonly known that laser tools can cause damage to the skin and the eyes not only of the user but also of the patient. For this reason a classification in correlation with the possible laser hazards exists, categorizing the devices in 4 diverse classes. All lasers used in dentistry belong to the III and the IV class. This means, that improper use of the machine can severely harm the operator, the patient or someone without the necessary protection. More specifically, in class IV lasers belong all the devices emitting with a power more than 0,5 W. They can be really harmful to the skin or the eye if viewed directly without the protective glasses. It can be also easily flammable increasing the chance for an undesired fire when it comes in contact with easily burned objects.

LSO or Laser Safety Officer is a worldwide recognized profession, which is responsible for guiding laser practitioners and makes sure that the necessary environment can guarantee the safety of the procedure. Included in the duties of an LSO is to be always present while a procedure with a class III or IV is going on. Also, he has the right to intervene when something is not according to the protocol. He checks that the sign 'laser in use' works and he has to control and inspect the machine looking for possible errors or not well working parts. He is also responsible to ensure that everyone in the operating room wears the special designed eye protecting glasses. Finally, he has to check the emission of the laser machine periodically by calibrating the performance of the device while he ensures that the settings are corresponding to the respective procedure needs. Additionally, he ensures that the protocol is followed so there is no probability of an undesired fire and that a high volume suction protects from the hazards of the produced laser plume. (Piccione 2004)

3.3.5 Lasers in practice

Er:YAG laser devices are more and more frequently used in the field of dentistry. In many different cases it can replace the conventional technique, offering considerable advantages to both the clinician and the patient. Furthermore, laser use, has quite wide spectrum and is becoming a very promising alternative in paediatric dentistry. The erbium family of lasers, offers the possibility of a painless procedure, often without anaesthesia need, with no use of drilling handpieces and without any thermal damage of the pulp when used with water cooling. These factors make the process much easier and well accepted from the small patients. (Walsh 2003).

In an in vitro study, Cavalcanti et al (2003) investigated whether there is difference in pulp temperature increase when Er:YAG laser or high-speed handpieces are used. They concluded that there is no difference when both systems are used under water cooling, something very essential to the maintenance of a healthy pulp with a temperature rise less than 5,5 ºC. These results come in accordance with the outcomes of two previous studies. Armengol et al (2000) and Mehl et al (1997) concluded that Er:YAG laser used with water cooling are totally safe for the dental procedures without any significant pulp temperature rise. At a more recent literature review by Bader and Krejci (2006) , they found out that when Er:YAG laser was applied along with water cooling , there was first a temperature decrease due to the water and then an increase of maximum 5 ºC when different energy volumes were used.

Micromorphology of the tooth enamel, dentine and adhesive systems in laser prepared cavities has already been examined in many different studies. Mineral content of lased surfaces was proved to be similar to those of non lased teeth, in an in vitro study in primary teeth. Also, settings of 4 and 3,5 did not show any significant difference with energies 200 mJ and 175 mJ respectively (Guler et al 2014). Aranha et al (2007) evaluated the adhesive systems interactions in cavities ablated from laser and burs separately in an in vitro study. Er:YAG laser was used in settings of

250 mJ energy in a frequency of 4 Hz under water cooling in a non contact mode. They concluded that resin tags were more pronounced in the lased dentine and that the cavities appeared to be more irregular. These characteristics come in accordance to the previous ones describing the dentine surface after laser treatment more rough and irregular, with open tubules and without smear layer. (Harashima et al., 2005) These features are considered ideal for achieving a good bonding between the resin and the dentine. (Ceballos et al., 2001) However, in the current study, some gaps were observed between the dentine and the resin, probably due to a collagen alteration. Further investigation is necessary in order to understand this possible side effect because if collagen is destroyed or compromised, the ability of the monomers and polymers to penetrate in the dentine is much lower. (Nakabayashi 1997)

Armengol et al (2003) suggested that laser treatment increased roughness and free energy of surface. This means that it makes it easier for the adhesive components to spread on the tooth surface and to achieve a very good contact with the tissues. Moreover, in cavity class V preparations with Er:YAG laser, irregular, rugged surfaces with open tubules were observed in an in vitro study of Harashima et al (2005). In another study, Esteves-Oliveira et al (2007) found that a self-etching primer had significant higher results in surfaces treated with the conventional burs.

There is discussion around the efficacy of laser devices to be used as an alternative to the etching technique. Insua et al (2000) concluded that bond strength for acid etched enamel and dentine was significant higher in comparison with surfaces treated only with laser. Bertrand et al., (2004) showed that with acid-etching use after the irradiation, the diameter of the resin tags was increased while funnel-shaped tags and a hybrid layer were observed. In addition, De Moor and Delme (2010) concluded that conventional acid etching technique cannot be skipped when laser is used for conditioning of the tooth surfaces. (Bader et al., 2006) They also found, a reduction in the bond strength due to a subsurface damage when laser was used. This comes in accordance to studies suggesting a damage of the collagen structures below the tooth surface but further research is needed for that. They also propose, that cavity finishing on the margins should be done with lower energy appliance avoiding the subsurface damage while they recommend the development of new adhesive materials specially addressed for the lased surfaces due to their different characteristics.

Composite resin restorations combined with pre-treatment using Er:YAG laser has also been studied a lot. Shigetani et al., (2002) found in an in vitro study, no differences in the marginal leakage of enamel or dentine and composite resin, when compared with the conventional bur-drilling technique. Er:YAG was used in an output energy of 200mJ/pulse with a repetition rate of 10 pps for the enamel and a tip of 0,6mm diameter. Another in vitro study of Baghalian et al., (2012) reached the conclusion that Er:YAG laser used in combination with a two step self-etching adhesive for occlusal and gingival resin composite restorations in primary teeth, showed much better marginal sealing comparing with the bur-prepared cavities.

On the other hand, Chinelatti et al., (2006) found that Er:YAG laser negatively influenced the marginal microleakage of Cavity V resin restorations. Kornblit et al., (2008) treated 30 cavitated teeth with Er:YAG laser in children from 4 to 12 years old and in a follow up period of one month no pain or pulp necrosis sign was shown.

Juntavee et al., (2013) found the same as Chinelatti et al., for Glass ionomer restorations in primary molars. Another interesting study from Shirani et al., (2013) showed that distance of irradiation can significantly influence the quality of the bond strength between composite and enamel or dentine. More the distance leads to better bonding strength between these surfaces.

Many applications of the Er:YAG lasers are now available in the field of Paediatric dentistry. Depending on the tissue which will be irradiated, different settings should be applied on the device.

- Enamel: 4-8 W
- Dentin: 2-5 W
- Caries: 1-3 W
- Bone: 1,5-3 W
- Soft tissue: 1-3 W

Also, different tips are available in the market. An interesting method is using a tip of 0,6 mm firstly and then targeting a more precise and highly dense beam by using a smaller tip of 0.4 mm always under water spray cooling. The best distance of an erbium laser tool is around 0,5 to 2 mm depending on the procedure and the instructions by the manufacturer. Metal matrixes can be freely used as laser does not give an interaction with them. This is not the case for composite resin restoration as if they come in contact with the laser beam they will be immediately ablated.

Er:YAG laser can be used for microdental caries removal, for large occlusal lesions, for class II, III, IV, V restorations with soft tissue removal if needed. Also, procedures like fibroma removal on buccal mucosa, frenectomy, sectioning of tooth, bone ablation and crown lengthening can be undergone by using the erbium-family lasers. (Lawrence 2004)

3.3.6 Lasers and pit and fissure sealings

Pit and fissure sealants with the use of an Er:YAG can be used for the paediatric patient. Hossain et al., (2000) carried out a study supporting the caries-preventive effect of laser irradiated enamel, as it degenerates and melts enamel and dentine making them more acid resistant. According to Kato et al., (2003) there is no need for anaesthesia, since the patient does not feel any pain. Moreover, the overall patient's experience is positive since the noise and the view of the drilling machine is avoided. Moshonov et al., (2005) concluded in an in vitro study that no difference was noted between lased and acid etched enamel surfaces for sealants application. This means that laser device can be an alternative with no additional etching of the surfaces according to the authors. Youssef et al., (2006) in an in vitro study compared the laser and the conventional technique for a sealant application. They concluded that no significant difference existed when acid etching followed the enamel conditioning. When only the Er:YAG laser was used, the highest degree of leakage noted on the samples. An in vitro study of Lupi-Pegurier et al., (2007) strongly supported that the enamel conditioning with the Er:YAG laser(E=250 mJ, f=4 Hz) should be in combination with the acid etching, in order to achieve the less microleakage values.

Lepri et al., (2008) performed a study to observe if laser treatment can produce more bond strength in a salivary contaminated environment. The conclusions were that laser was not able to increase the bond strength of acid etched surfaces either on dry or wet conditions. Olivi et al., (2009) concluded that the Er:YAG laser should still be used after acid-etch enamel pre treatment. Baygin et al., (2012) showed that laser irradiation cannot eliminate the use of acid etching technique applied for pit and fissure sealants, being in accordance with the study of Lupi-Pegurier et al., (2007). An in vitro study by Topaloglu-Ak et al., (2013) comparing different surfaces treatments for the use of pit and fissure sealants, concluded that the less microleakage values were in the group treated with laser irradiation (P=2.5 W, E=125 mJ, f=20 Hz, non contact mode) followed by 37% orthophoshoric acid etching. This can be explained by the irregular edges produced as well as due to the enamel-etching like pattern on the teeth. (Matson et al., 2002) .

An in vitro study performed by Eltigani et al., (2013) concluded that Er:YAG irradiation with acid etching technique and conventional sealant use had less microleakage scores compared to the non invasive or to the bur-prepared enamel either followed by acid etching or not while non invasive sealing treatment had very low success rates. In a study over fluorosed teeth from Memarpour et al., (2014) they found that laser irradiation in combination with acid etching had the similar results in occlusal sealing microleakage comparing to the conventional acid etching technique. Finally, acid etch should be used after the enamel conditioning with the laser according to Nazemisalman et al., (2015)

3.3.7 Lasers and children's comfort

A study from Keller et al., (1998) compared the comfort during the use of Er:YAG laser for cavity preparation in adult patients in comparison with the rotary instruments. They showed that there was significantly less discomfort in the group of patients treated with the Er:YAG laser. Local anesthesia was administered only after request of the patient. Another split mouth study from Dixit et al., (2013), proved that Er:YAG laser preparation for Class I cavities was much more comfortable for adult patients when compared with the conventional bur handpieces. Those results are quite normal because it is proved that Er:YAG laser can be used for cavities without any anesthesia while this is not the case for rotary instruments.

In paediatric dentistry there is a special need to maximize the comfort of the small patient by creating a pleasant and pain free experience. There are already some studies trying to investigate if an ER:YAG laser can be accepted better for cavity preparations or pit and fissure sealings in paediatric patients in comparison to the conventional handpieces. Evans et al., (2000) in a randomized controlled trial, tried to determine if the Er:YAG laser or the conventional handpieces were more acceptable for patients more or less than 10 years old. The first group of patients (>10 years old) showed a significant preference for the laser preparation while in the second group of patients there was no clear preference between the two techniques when scored with a simplified pictorial questionnaire.

Kato et al., (2003) in a clinical study on children ranging from 2 to 12 years old, applied Er:YAG laser for cavity preparation without anesthesia. Almost all the children did not show any sign of discomfort or unpleasant feeling and pain. Another split mouth comfort study from Liu et al., (2006) showed a much better comfort level on patients from 4 to 12 years old when Er:YAG laser was used compared to the conventional handpieces for the treatment of two anterior carious teeth in every patient (total 40 patients). They also mention that the children showed much more body and head movement during the mechanical preparation with the bur and they emphasize that despite the fact that the laser preparation took more than double time, they choose it as their treatment of choice for a future appointment.

In addition, the results of the previous study are similar with those of Bohari et al., (2012) where he used 120 teeth from children among 5 and 9 years of age to compare the level of comfort during different caries removal procedures. They divided four groups (Air Rotor, Carisolv, Chemomechanical caries removal, Er:YAG laser) and they used the FLACC (Face, Legs, Activity, Cry, Consolability) scale to evaluate the comfort of the children. They concluded that laser was as comfortable as chemomechanical excavation and more acceptable than the air rotor handpiece. In another study from Turkey, Eren et al., (2013) found more patient comfort during treatment for cavity preparation when the Er,Cr:YSGG was applied in comparison with the mechanical handpieces. However small sample size and other study limitations can question the results.

In a study of Belcheva et al., (2014) patients from 6 to 12 years old with caries D3 (WHO criteria) were divided in two groups. The first was treated with ER:YAG laser and the other group with the conventional handpieces both without anesthesia. Every child had to give a score in a pain scale. There was significantly less pain experience in the first group of the treated children when the ER:YAG laser was used. The result seems to be more than logic taking into consideration the fact that it is totally not recommended treating caries D3 degree without anesthesia when rotary instrumentation is used.

3.4 Dental Fear and Anxiety

3.4.1 Age

There are several differences between dental fear, dental anxiety and dental phobia. In the first case, the child has a normal reaction and it is mostly correlated with a specific stimulus or an object. Anxiety can be provoked without any specific condition, it is not linked to an object and it is considered an abnormal condition. A more severe type of anxiety is phobia where the patient has a tendency for avoidance of concrete objects and situations. In most of the cases this condition interferes with the daily life of the patient.

Different factors can play a great role on how the child will face the dental visit. It is a combination of personal characteristics, external influence and certainly the age and the cognitive level of the patient. There are four different levels of pain perception according to the age. (Piaget et al., 1969)

- **0-2 years old Sensory motor stage**
- **2-7 pre-operational stage**
- **7-11 concrete operational stage**
- **11-14 formal operational stage**

Children from 7-11 years old share the same characteristics when they face a new stimulus like the dental visit. They are at a very concrete operational stage while they seem to be very interested and attracted by how the dental machines and drills work. They want to know and understand what the role of every single instrument is. Some of these patients still consider pain as a punishment for something that they did not do in the right way. A child of 9 years old is at a transient period when he is able to discuss what he is thinking. He understands the authority of the dentist, the meaning of death and life, he can open a dialogue using adult language but it remains difficult to understand everything. Last but not least, the child can realize why preventive measures are important and he wants to be honest, believing that everybody will be like this. (Welbury et al.,2012)

3.4.2 Pain scales

It was always a big matter of discussion how to evaluate and measure pain perception and characteristics among different age groups of children. Correct assessment and measurement of pain demands taking into consideration children's age, cognitive level, developmental level, ability to communicate, personal experience, fears and beliefs. Pain assessment can be categorized into self-report, behavioral or physiological measures. Visual analogue scales and facial expression scales are tools of the self-report measurement while children with communication problems and special care need are monitored by behavioral methods focusing on movements, reactions, expressions and crying . The FLACC observational pain scale is commonly used for those children as well as for young patients between one and six years of age. (Nutter 2010) The most prevalent physiological measures used to assess pain in children are the heart rate, blood pressure, respiration rate and oxygen saturation rate. (Jain et al., 2012)

For the group age of 7-11 years old, there is strong evidence that supports the use of one of the following face pain scales.

- Faces Pain Scale-Revised (FPS-R)
- Wong Baker Faces
- Oucher scale
- Visual Analogue scale

The first one seems to be superior when comparing with the rest. It can be used for school age children (4-12 years old) and it is considered to be the most reliable and valid scale for acute pain perception. (Fig 7) (Tomlinson et al., 2015)

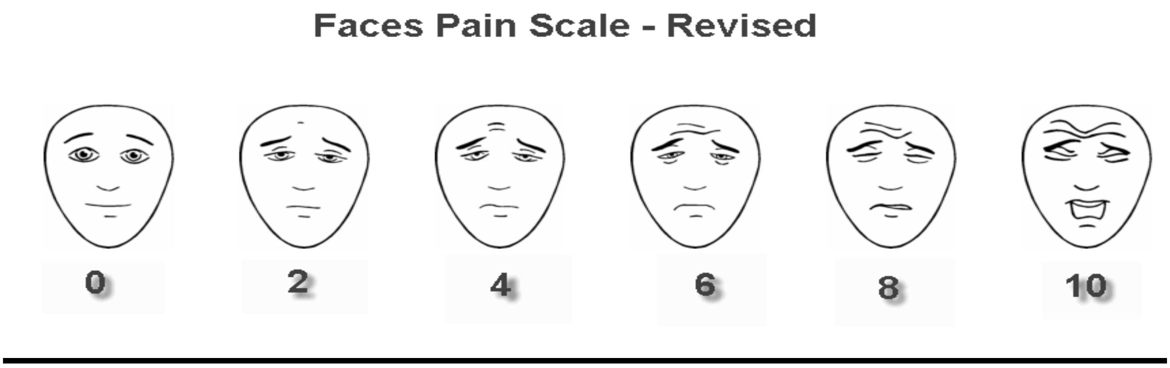


Figure 7: Faces Pain Scale-Revised

The first Faces Pain Scale that was developed consisted of seven different neutral faces. The revised version has six faces gradually ranging from no pain to severe pain. Each face of the new scale can be assigned with a number starting from 0 to 10. It is quite a simple procedure and it is simple enough to explain the idea to the child. This method has been used for children of 3 years old with success. At the end of the treatment the numbers can be corresponded to no pain, mild pain, moderate pain or severe pain. (Hicks et al., 2001)

The Wong-Baker Faces is quite similar to the FPS-R but it has been accused that the first and the last picture can influence the decision of the young patient (big smile and tears) leading to a wrong interpretation and correspondence of the emotion with the picture. (Fig 8) (Drendel et al., 2011)

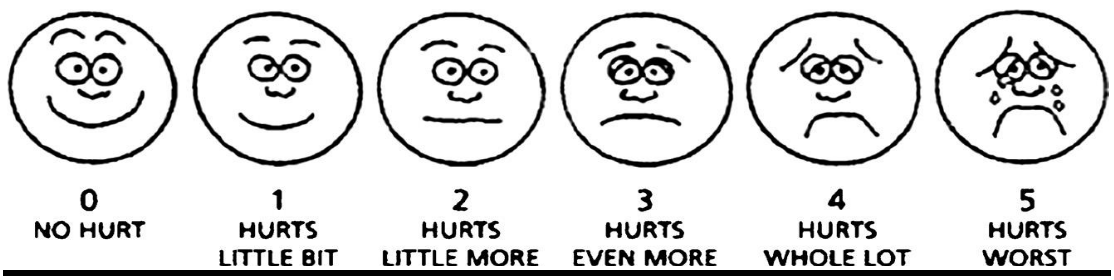


Figure 8: Wong-Baker Faces

This is in agreement with a study from Chambers et al (1999) where parents and children had to choose the best pain scale in their opinion. Most of them voted for pain scales containing happy or cartoon-like faces (cute faces) resulting though in biased results due to the distractive effect of those scales when compared with the use of neutral faces (FPS-R). (Chambers et al., 1999)

Oucher scale seems to be quite complicated and costly. (Drendel et al., 2011) It is consisted of 6 different children pain faces (photos), vertically adjusted and from different origins. It can be used for children which are older than 6 years old and it can be scored from zero to five or to ten. (Fig 9) The Visual Analogue scale is for children above 8 years of age and demands more explanation and abstract thinking for the patient. (Drendel et al., 2011)

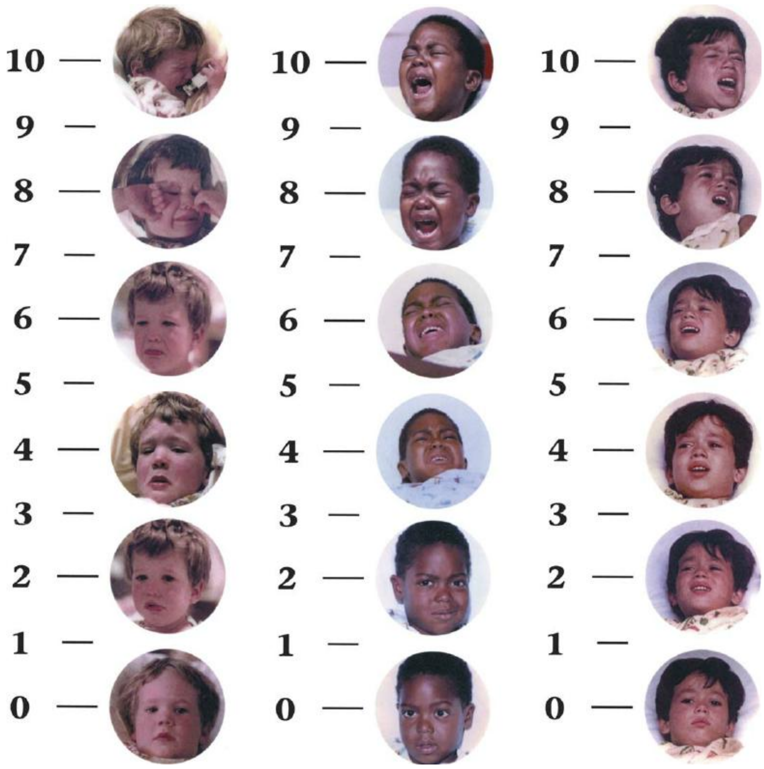


Figure 9: Example of the Oucher pain scale

In addition to the face pain scales, a verbal pain measure was added to the current study increasing the reliability of the answers, providing the patient with the possibility to describe better how he felt during the procedure. We used a modified and translated Likert scale which has been proven to be a well established method which can be applied to children especially at the age group of our study (7-11). Likert scale in general comprises a five-point scale (strongly agree, agree, neutral, disagree, strongly disagree) followed by a statement in each case (Fig 10). It was also shown that the patients themselves find it a very easy and quick procedure when they were asked to score their level of comfort comparing to the numeric and the visual analogue scale. (van Laerhoven et al., 2004)

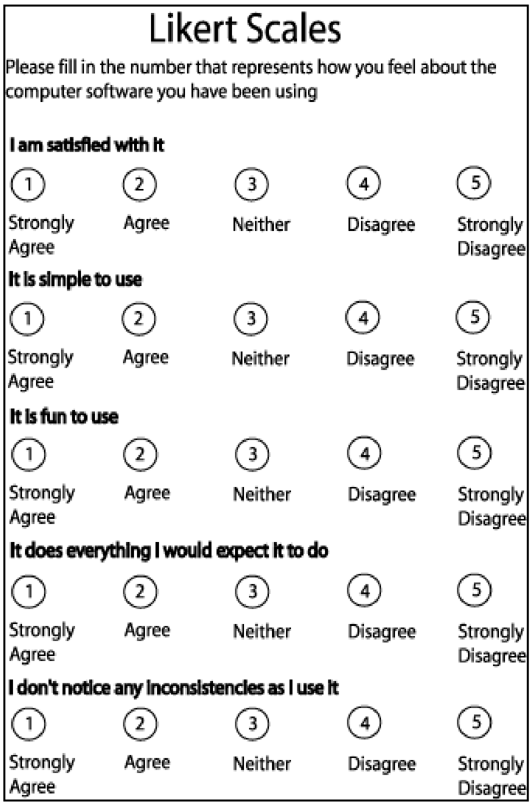


Figure 10: Example of Likert scale measuring

4 Aim

The aim of the current study was to evaluate the comfort of children aging from 7 to 11 years old when two different techniques were used (Bur handpiece – Er:YAG laser) for the invasive preparation before the application of pit and fissure sealants. The sealing application followed the EAPD guidelines. (Welbury et al., 2004)

For the needs of our study, a PICO question was developed according to Santos et al., (2007). Formulating a PICO question helps the researcher to focus on the most important things of the study. Furthermore, the keywords are defined making it easier to find relevant literature. In our study the type of the PICO question that we created was from the category of prevention and therapy and stands for the following elements:

Will the use of Er:YAG laser compared to conventional handpieces (C) result in more comfort (O) during pit and fissure sealant procedures (I) in 7-11 year old children (P)?

The null hypothesis was that the use of Er:YAG laser would lead to more comfortable and relaxed patients when treated for pit and fissure sealants application.

5 Materials and Methods

The clinical project comprised patients who were 7 to 11 years old and in need for pit and fissure sealants on the deep fissures of two permanent molars which are located bilateral in the mouth and in the same jaw. The quadrants were allocated according to the double coin technique, heads or tails, in a split mouth design to either Er:YAG (Erbium-Yttrium Aluminium Garnet laser device, Fotona AT Fidelis, Stegne 7, 1000 Ljubljana, Slovenia Eu) laser preparation or the conventional invasive technique with a bur. Informed consent was signed by the parents and they were informed about the procedure and the technique of the laser device. The oral hygiene index according to Greene and Vermillion (1964) as well as the caries-risk was scored prior to the treatment. Various parameters were also noted like the different origin of the patients, possible experience with the traditional handpieces or the laser, age and gender.

5.1 Ethical committee

The current study was approved from the Ethical committee at the University Hospital of Ghent following the International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use guidelines which is based on the Helsinki Declaration of Human Rights (Registration number: B670201629098, year: 2016). The protocol as well as the materials and the devices were approved for use while the inform consent which had to be signed from the parents, gave them all the necessary information and enlightenment concerning the treatments, the possible ‘risks’ and the safety measures for the use of the laser machine.

5.2 Sample size and selection

Forty one patients were chosen from the Paediatric dental clinic of the University hospital of Ghent aging between 7 and 11 years old, in need of pit and fissure sealants according to the EAPD guidelines. (Welbury et al., 2004) A preliminary analysis when twenty patients were treated showed that fourty patients can be enough for the aim of our study. The patients had two first or second molars to be sealed, located at the same jaw but at a different quadrant. Patients were first examined in the Paediatric dental clinic, visually and radiographically with bitewings, following the ICDAS scores (Fig 11). (Pitts et al., 2013) Once we ensured that they met the inclusion criteria for our study, the protocol and the procedures were explained to the parents, giving them on parallel the inform consent which had to be signed. If they agreed a new appointment was made at another date since it was necessary to reserve a specific room in accordance to the safety measures during the use of a laser.

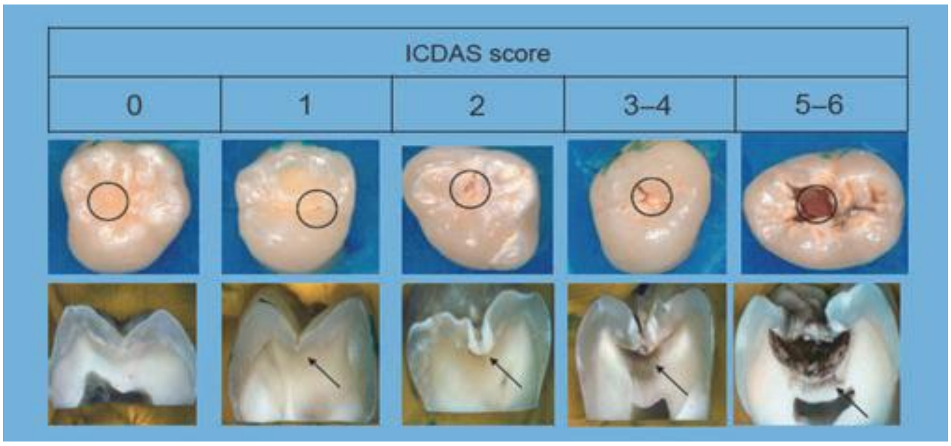


Figure 9: ICDAS clinical visual codes

5.3 Inclusion criteria

- ASA 1 patients
- Age from 7 to 11 years old
- Cooperative children
- First or second primary molars in need of sealings according to the EAPD guidelines

5.4 Exclusion criteria

- Uncooperative children

- Medically compromised
- Not fully erupted molars
- Molar Incisor Hypomineralisation (MIH)
- Dentinogenesis Imperfecta
- Amelogenesis Imperfecta
- Bruxists

5.5 Devices and Settings

Two different enamel ablating techniques were used in the current study in order to condition the enamel before the application of the acid-etch gel and the pit and fissure sealant. The traditional high speed handpiece (Fig 12) (Synea Fusion WG-99LT, W&H, Austria) was used in combination with a burr no.8833314031 (Fig 13) under water spray.

Figure12: Synea handpiece

Figure13: Umbrella bur for pits and fissures

On the other side the Er:YAG laser (Fotona AT Fidelis, Stegne 7, 1000 Ljubljana, Slovenia Eu) (Fig 14) was used with a handpiece R14 on a VSP mode with an energy of 250 mJ at a frequency of 30 Hz (pulse per second). The power that was used was 7,5 W and the fiber tip that was used in contact with the tooth surface was the Conical Sapphire (Fig 15) in a diameter from 0,8mm to 1,3mm, length 12mm and maximum energy setting 350 mj. (Lukac et al.,2007)

Figure14: Er:YAG laser (Fotona AT Fidelis)

Figure15: Conical Sapphire fiber tip

5.6 Clinical Procedure

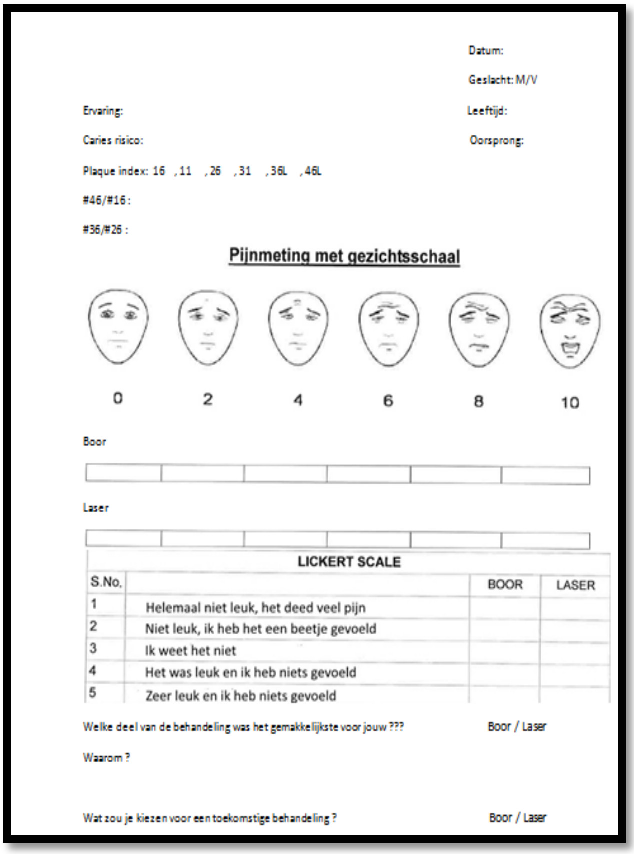
All the treatments were done by a single operator (master student University of Ghent) accompanied by an assistant during the clinical process. After the use of the double coin technique for the selection of the side and the device to start with, we demonstrated to the patient out of his mouth the way that every machine works and the noise that it makes. During the treatment cotton pellets were used for isolation while the aspiration was placed in the mouth and the surgical aspiration was held by the assistant during the use of the device. When Er:YAG laser was used, the child, the operator and the assistant were asked to wear the protective glasses. Ultra-Etch 35% phosphoric acid solution was used for thirty seconds, followed by rinsing with water spray and drying, before the application of the light-cured Delton Pit and Fissure sealant (Dentsply international, Signaalrood 55, 2718 SG Zoetermeer, Nederland). Occlusion was checked and adjusted when needed.

5.7 Pain assessment-Questionnaire

After preparing each tooth the patient was asked to score pain sensation during the treatment on the revised-faces pain scale from 0 (no pain) to 10 (extremely painful), followed by completing a five point Likert Scale. (Fig 16) It is clear that this procedure happened two times, immediately after the application of every single machine to avoid any overlap or confusion when scoring the two different devices. He was first asked to choose a face that represents how he felt during the procedure. Then, the five different sentences were read to him (they also took their time to read them themselves)

- Totally not nice, very painful
- Not nice, I felt something
- I don't know
- It was nice and i felt nothing
- Very nice and i felt nothing

Once both treatments were completed, the patient was asked to assign the preferred one, giving on parallel evidence for his choice. Finally, he was asked which device he would prefer for a possible future treatment.


Datum:
Geslacht: M/V
Ervaring:
Leeftijd:
Caries risico:
Oorsprong:
Plaque index: 16 ,11 ,26 ,31 ,36L ,46L
#46/#16:
#36/#26 :

Pijnmeting met gezichtsschaal

0 2 4 6 8 10

Boor

Laser

LICKERT SCALE

S.No.		BOOR	LASER
1	Helemaal niet leuk, het deed veel pijn		
2	Niet leuk, ik heb het een beetje gevoeld		
3	Ik weet het niet		
4	Het was leuk en ik heb niets gevoeld		
5	Zeer leuk en ik heb niets gevoeld		

Welke deel van de behandeling was het gemakkelijkste voor jouw ??? Boor / Laser

Waarom ?

Wat zou je kiezen voor een toekomstige behandeling ? Boor / Laser

Figure 10: Revised-faces pain scale Lickert

5.8 Statistical Analysis

For the analysis of the collected data SPSS 22 was used. A significance level of 0.05 was adopted.

6 Results

6.1 Descriptive results

A total of 41 patients participated in the study, varying from age between 7 and 11 years old. (Fig 17)

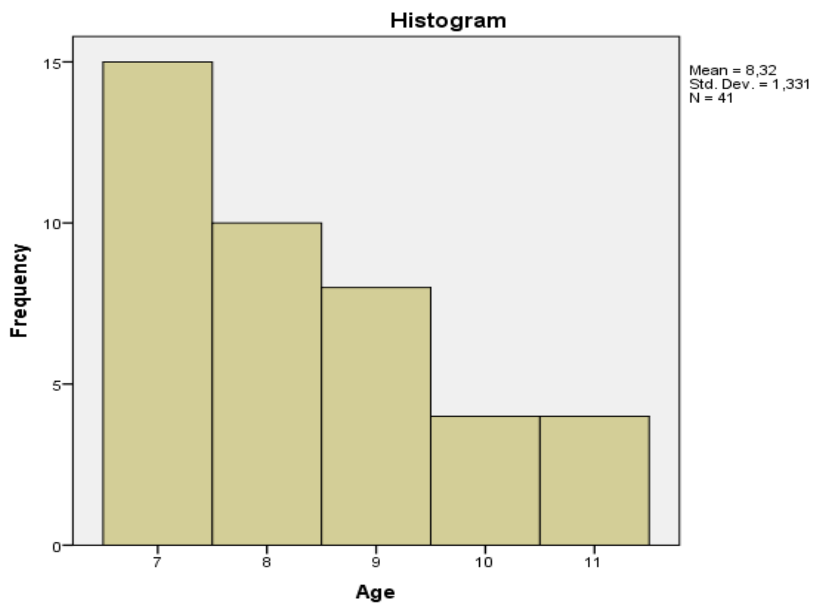
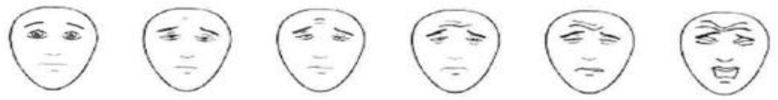


Figure 11: Age distribution of the 41 patients

82 teeth were sealed, half of them were pre-conditioned using the bur and the other half by using the Er:YAG laser device. In every child, the technique for every tooth and the side to start with were selected by using the double coin technique. From the 41 patients, 21 (51%) were girls and 20 (49%) were boys while also 21 (51%) children did not have any experience with both techniques. 15 of the patients (36,5%) were from Belgium followed by 8 (19,5%) Turkish children and 4 from Bulgary (9,7%). The rest were from different origins including France, Philippines, Pakistan, Algeria, Burundi, Kosovo, Senegal and Colombia. 29 patients (70,7%) scored in favour of the bur when they were asked which procedure was easier for them. The different answers for the Revised-pain faces scales are shown in the following figures. (Fig. 18,19)



	0	2	4	6	8	10
Total Bur	28	10	2	1	0	0
Girl	16	3	1	1	0	0
Boy	12	7	1	0	0	0
Total Laser	19	15	4	2	0	1
Girl	10	7	2	1	0	1
Boy	9	8	2	1	0	0

Figure 12: Distribution of the Revised-Pain faces scales scores between girlsand boys

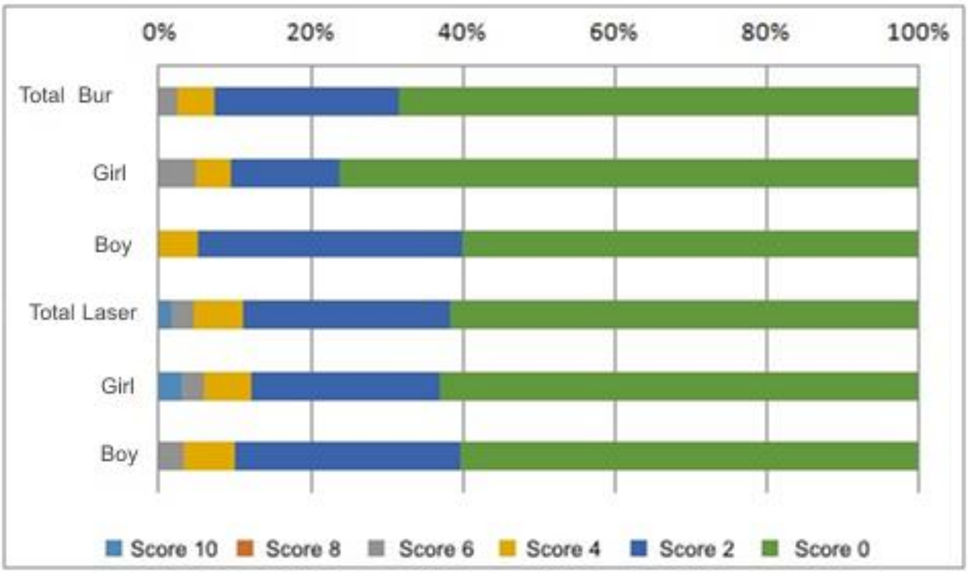


Figure 13: Distribution of the Revised-Pain faces scales answers in percentage

Analysis of the answers on the Likert scale was in agreement to the R-PFS results showing a clear preference for the bur. (Fig 20,21)

	Not funny at all, very painful	Not funny , I felt it	I don't know	Funny, I did not feel anything	Extremely funny, I did not feel anything
Total Laser	1	10	12	5	13
Girl	0	6	6	1	8
Boy	1	4	6	4	5
Total Bur	1	1	10	14	15
Girl	1	0	5	8	7
Boy	0	1	5	6	8

Figure 14: Distribution of the Likert scale answers between girls and boys

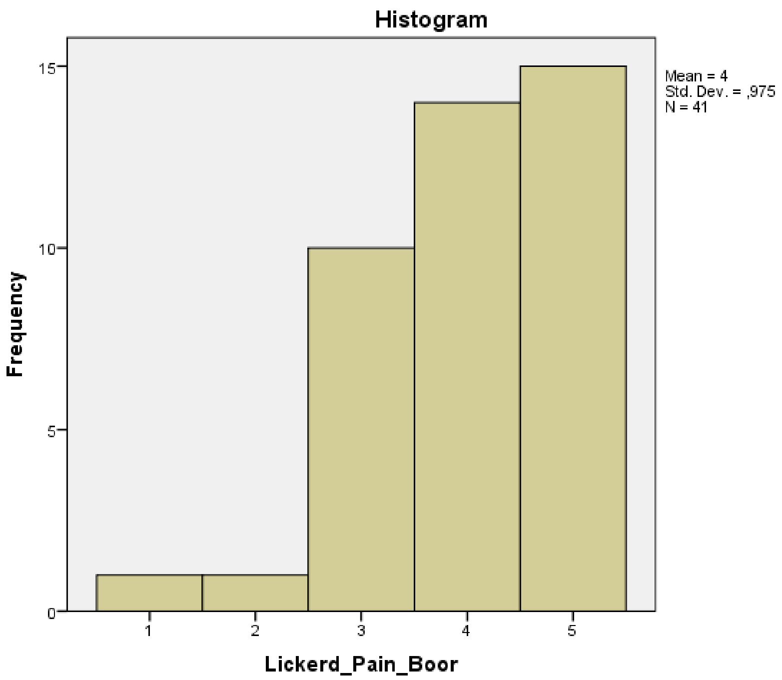


Figure 15: Histogram showing the answers for the bur on the Likert scale 1-5

6.2 Statistical Analysis

For the non-parametrical results obtained by the Likert scale and the revised-pain faces scales, the non parametric Wilcoxon Signed Ranks test was used. There was a significant difference in pain perception between bur and laser, when measured with pain faces ($P<0.05$) as well as when measured with a five point Likert scale ($P<0.05$) in favour of the bur. In general laser was perceived more painful than the bur. When the children were asked what they would choose for a future treatment, all their answers were in agreement with their previous answer about which treatment was easier for them (100%).

It is important to mention that statistical analysis (Kendall's tau correlation) showed a very significant correlation between pain faces and Likert scale at a moderate degree t=0.51 for bur and t=0,53 for laser ($P<0.0005$). In addition, there was a significant relation between children mentioning noise for the laser on their comment when they were asked the reason for their choice and their preference for the bur. ($P<0.005$). Finally, no differences were detected between boys and girls, experienced and non experienced children and between patients of different nationalities.

7 Discussion

The results of the current study clearly indicate that the children had a significant preference for the bur in comparison with the use of the Er:YAG laser. We tried to limit the age range of the patients in order to achieve a more relevant spectrum of answers. In fact, all patients (n=41) were of a similar cognitive level (7 to 11 years old) being very interested in how everything in the dental practice works. Children at this age want to understand the different role of the different machines and sometimes they still believe that if they feel pain it is because they are punished for an inappropriate behavior. In general, they try to be honest, expressing their real feelings which gives more reliability to their answers. It is important to mention that all children’s answers for the revised-pain faces scales and the Likert scale were in agreement with their choice at the end.

It is quite interesting to see what the answers of the patients were for the open questions. Most of the patients who rejected the laser and choose the bur, commented that the Er:YAG was noisier. We know that both preparation techniques are making noise but it seems that the children perceive this kind of continuous explosions noise more annoying and stressful for them. It is also remarkable that one child referred that even if he felt much more ‘cool’ with the ‘sunglasses’ of the laser, he felt much *more annoyed and stressed from the noise resulting in choosing the bur*. Another child said that he was happy that he saw something new like a laser but for him *the bur was clearly more easy and acceptable because of the less noise produced*. From all the patients, only one girl scored for the revised-pain faces ten for the laser. This was the only ten scored in the study while for the same scale she scored zero for the bur. At the end she choose the bur and she said that *she was afraid from the noise* when it was in her mouth despite the fact that she was already shown what to expect.

On the other side, only one child from those who chose the laser said that during the laser treatment he also felt nicer and happier because of the super feeling when wearing the ‘sunglasses’. This is a good example of the cognitive level of the children who were not enthusiastic and distracted by the protection glasses which was used during the laser treatment and they could distinguish what was asked by them and what was the meaning of the pain faces and the Likert scale. The rest of the positive answers for the laser were a result of more comfort during the Er:YAG treatment. In addition, from the children who choose the bur (n=29) only two mentioned that they still felt something with the bur but the laser was even more annoying because of the noise. Finally, it was impressive that one child pointed that *the noise of the laser was like small explosions*, something that is actually true, making him choosing the bur.

To our knowledge this is the first clinical laser comfort study which gives a result in favor of the rotary instruments. Previous studies in adults from Keller et al., (1998) and Dixit et al., (2013) found a preference for the Er:YAG laser for cavities preparations but we should take into consideration that local anesthesia was given only after request of the patient. Rotary instruments were never supposed to be used without the use of local anesthetics. It seems also to be a quite logical conclusion as we all know the ‘fear’ and the unpleasant feeling of most patients when they come to the dentist. In our personal view, answers of children can be much more honest comparing with those of adults.

The only study found to be close to this one was from Evans et al., (2000) who found no clear preference for patients lower than 10 years old between the two techniques when scoring with a simplified pictorial questionnaire. Another study from Takamori et al., (2003) examined in vitro the vibrations produced during tooth preparation when high-speed drilling and Er:YAG laser are used. They found that rotary instruments caused much more vibrations and they have a frequency spectrum near the high sensitivity of hearing when compared to the Er:YAG laser. This can lead to more pain and discomfort during the treatment according to the author. Important to note that the study was in vitro and the periodontal tissue was simulated by a silicon impression. Similar to the adult studies, Kato et al., (2003) used on children ranging from 2 to 12 years old Er:YAG laser for cavity preparation without anesthetics. Almost all the children did not show any sign of discomfort or unpleasant feeling and pain, possibly as a result of avoidance of the noise of the bur according to the author. In addition Liu et al., (2006) showed a much better comfort level on patients from 4 to 12 years old when Er:YAG laser was used compared with the conventional handpieces for the treatment of two anterior carious teeth in every patient (total 40 patients). In both studies the age range of the patients is extremely wide, making it almost impossible to correlate answers coming from a two or four years old child with those of a ten or twelve years old teen. Furthermore, Liu et al., (2006) used rotary instrumentation without local anesthesia in children something not advised especially in the paediatric dentistry.

As already mentioned, Er:YAG laser can be used for cavities without any anesthesia but this is not the case for the rotary instruments. The same applies for Bohari et al., (2012) who used 120 teeth from children among 5 and 9 years of age to compare the level of comfort during different caries removal procedures. They divided four groups (Air Rotor, Carisolv, Chemomechanical caries removal, Er:YAG laser) and they concluded that laser was as comfortable as chemomechanical excavation and more acceptable than the air rotor handpiece.

Eren et al., (2013) found opposite results to the present study, as he showed more patient comfort during treatment for cavity preparation when the Er,Cr:YSGG was applied in comparison with the mechanical handpieces. However small sample size and other study limitations can question the results. Last study with contradictory results to the present , is the study of Belcheva et al., (2014) where patients from 6 to 12 years old with caries D3 (WHO criteria) was treated with ER:YAG laser and the conventional handpieces without anesthesia. They found significantly less pain in the children who undergone treatment with the ER:YAG laser. The result seems to be more than logic taking into consideration the fact that it is totally not recommended treating caries D3 degree without anesthesia when rotary instrumentation is used.

Almost all comfort studies which are trying to compare Er:YAG laser with the rotary instruments, found similar results in favour of the bur which has led to the acceptance that Er:YAG can be used for deep cavities preparation. With respect to that, it is the author's opinion that it is wrong to conclude that Er:YAG can replace the rotary instruments in the pediatric dentistry in terms of comfort because it is unfair to evaluate rotary instrumentation when it is used without anesthetics. We all know that when handpieces with bur are being used for cavity preparation, local anesthesia is more than recommended in order to relax and not stress our little patient. In almost all previous studies, rotary instruments were used without anesthetics. That can be considered as a research bias because it can easily determine as result more comfort and less pain with the Er:YAG laser due to its different thermomechanical properties. Maybe Er:YAG laser can be a good alternative when local anesthesia cannot be given (anxious or patients with phobia) but studies have to be done for that to be proved. In the present study, it became clear that when both equipment is used following the guidelines, bur offered significantly much more comfort and relaxation to the patients.

8 Conclusion

Children felt much more comfortable when the traditional handpiece with the bur was used for pit and fissure sealings in comparison with the use of the Er:YAG laser. The null hypothesis was rejected as it was shown that the use of Er:YAG laser for pit and fissure sealings did not give more relaxation and comfort because of the increased and special noise that it produces. For the moment, bur handpieces should still be used for enamel conditioning for pit and fissure sealings when necessary while Er:YAG laser does not seem to be a realistic alternative.

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