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Ph.D. dissertation

THE USE OF THE OPERATING MICROSCOPE IN DENTAL PRACTISE: POSTURAL ANALYSIS AND CLINICAL EVALUATION

MED/28

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CONTENTS

INTRODUCTION

THE USE OF THE OPERATING MICROSCOPE AND MAGNIFYING SYSTEMS IN DENTISTRY

The first microscope-assisted surgery is traditionally attributed to Nylen, for an otologic surgery in 1922. Since then, microscope-assisted medicine has experienced an exponential growth of interest. Many years were needed to reach dental practice, even though the tininess of the structures to treat, and the degree of precision required for those treatments, seemed to call for immediate awareness of its potential. It was not before the late 70s, early 80s, that a microscope was used in dentistry. Before that date, in most cases, the first treatment option for dental diseases was extraction of the teeth and the use of a microscope was very remote from the immediate preoccupations of dentists (Sitbon, Attathom, & St-Georges, 2014).
Improving dental care shifted the focus to conservative treatment making necessary the use of minimally invasive techniques necessary. Nowadays, the goal of treatment is to preserve dental tissues with minimally invasive prosthetics, conservatives and endodontics therapies, and to reconstruct periodontal soft and hard tissues performing microsurgery treatments in order to get the best aesthetic results and the least pain and complications.
Over time, the degree of precision required for magnification. It is necessary to get the fine proprioceptive control needed to perform minimally invasive therapies. It has been known that the accuracy of fine motor skills is limited more by the eyes than the hands (Perrin, Eichenberger, Neuhaus, & Lussi, 2016a).

In dentistry we have two kinds of magnification systems: loupes and operating microscopes (Figure 1). The first is a wearable device, with a galileian or keplerian magnification system widespread used among dentists. Furthermore, it's possible to have a coaxial illumination that improve visual acuity in the oral cavity (Bowers, Glickman, Solomon, & He, 2010).

FIGURE 1 GALILEIAN LOUPE, KEPLERIAN LOUPE AND OPERATING MICROSCOPE (MOVENA) ZEISS ®

The surgical loupes have a single degree of magnification (2.5 to 5x), a binocular vision with optics converging toward the focal length, and the necessity for the eyes of the operator to converge and accommodate. On the other hand, they are relatively inexpensive, easy to learn and use.

The operating microscope offers a magnification ranging from 2.5 to 20x or more. You can change the degree of magnification depending on the procedure. The optics are large and of high-quality and at the same magnification, a microscope provides a better image than loupes: increased depth of field, vision, luminosity, resolution and sharpness, decreased distortions and spherical and chromatic aberrations. Moreover, the optics of a microscope are parallel, aligned with the axis of vision at infinity. The eyes of the operator do not need to converge or to accommodate; which completely removes any strains from them, even when using the highest magnification. When working under a microscope the dentist looks right in front of him/her, and not at the operating field. Whereas when you wear loupes; you can't stay in an upright position (Sitbon et al., 2014). It's a cumbersome and expensive device, but it is highly superior visually and ergonomically. Furthermore, it's possible to display on a monitor what the surgeon's eyes see and it is possible to record the whole intervention easily.

	Galilean loupes are the most common type of loupe in dentistry. They have a typical conical shape. The optical system consists of a combination of convex and concave lenses, the working distance of which can be adjusted to the given ergonomic needs. Although the magnification factor is physically limited to 2.5×, it is possible to reach a higher magnification of up to 3.5×, albeit with optical compromises (limited field of vision, blurring around the edges) (Perrin et al., 2016).

Table 1Galileian loupe, Carl Zeiss®

	Keplerian loupes are characterized by their cylindrical shape. Keplerian loupes consist of a complex convex optic system of lenses and prisms. This system allows various magnifications and working distances. The preferred range of magnification in dentistry is between 3.5× and 6×, in order to minimize the influence of the limited depth of focus. The considerable optical advantage over Galilean loupes is offset by greater weight and higher price (Perrin et al., 2016).

Table 2 keplerian loupe, Carl Zeiss®

	Operating a microscope offers various magnification settings and orthograde illumination of the working area. Due to the depth of focus and overview, the most common magnification used in dentistry is between 4× and 10×. The working distance is adjusted to the height of the surgeon by choice of objective. The surgical microscope has significant ergonomic advantages based on the upright sitting position (back and cervical vertebrae) the surgeon can adopt, and the fatigue-proof, parallel line of view without having to adjust oneself (Perrin et al., 2016).

Table 3 Operating Microscope Movena, Carl Zeiss®

A recent review (Perrin et al., 2016a) on visual acuity in dentistry, studied the ability to perceive fine details of an object, by comparing all magnification systems with the naked eye.

Galileian loupes, Keplerian loupes and the Microscope were considered in two groups of practitioners divided depending on age, less than 40 years or older. This study is critical because it shows that age can affect visual acuity and how the type of magnification device can improve it.

Based on the results of this research and other studies (Sitbon et al., 2014) the microscope seems to be the better choice to get the best results in terms of visual acuity for a dentist.

Although the use of the microscope is increasing and the benefits of optical magnification have been recognized, its general use remains limited in dental practice (Carpentier et al., 2019).

It can be explained by the fact that the operating microscope is used mainly in endodontics, for the advantage of high magnification that is essential to more efficiently examine, clean, and shape complex radicular anatomy. The high cost and the mistaken belief of the limited use in dental practice make this device not so familiar in dental offices.

In the United States, the use of the operating microscope by endodontists increased from 52% in 1999 to 90% in 2007 (Kersten, Mines, & Sweet, 2008). In the same period in Italy, the results of an investigation showed that almost 65% of dentists, active members of Italian Society of Endodontics, use the operating microscope (Riccitiello et al., 2012). However, based on data reported by companies in 2017 in Italy, only 3% of dental practitioners owned an operating microscope.

On the other hand, the use of surgical loupes is widespread, and more than 85% of dentists use different types of magnification during their daily work (Sitbon et al., 2014).

The learning curve was a big problem for the dentists, and they always thought that the use of the microscope for non-static interventions, as for endodontics, it would be a problem instead of an aid. However, this is a false problem because most of the dentists who experienced the use of magnifying devices and the higher the use, the faster the adaptation to an operating microscope. It needs a relatively flat learning curve that links to maneuverability and quality of the lens and illumination.

Main advantages of the microscope are not only the possibility to reach high magnification, but also to change the distance work and depth of field, keeping an upright position, and being able to quickly generate a pre-, per-, and post-operative iconography of the treatments. All these advantages could be applied not only to endodontics but can be used in other areas as well.

Nowadays, thanks to technological progress and cost reduction, there’s growing interest for this magnification system. Potential applications could be greater than previously believed.

WORK-RELATED MUSCULOSKELETAL DISORDERS AMONG DENTAL PRACTITIONERS

According to the World Health Organization (WHO), the term work-related musculoskeletal disorders (WMSDs) describes a “wide range of inflammatory and degenerative diseases and disorders that result in pain and functional impairment. They arise when individuals are exposed to work activities and conditions that significantly contribute to their development or exacerbation, but which may not be their sole cause”. Healthcare workers, especially those with direct patient contact, are amongst professions with the highest rate of WMSDs due to their job demands and positions maintained throughout the day. WMSDs are classified as ‘Clinically well-defined disorders’ (e.g. Carpal tunnel syndrome (CTS), tendinitis, hand-arm vibration), ‘Less clinically well-defined disorders’ (e.g. tension neck syndrome), and ‘Non-specific’ (e.g. Repetitive Strain Injury, CTDs, overuse syndrome, cervicobrachial disorders) (WORLD HEALTH ORGANIZATION GENEVA 1985).

WMSDs are identified as injuries that can occur from a single event, or cumulative trauma including any complaint, from slight transitory discomforts to irreversible and incapacitating injuries.

Attention and awareness towards WMSDs in the dental profession has increased considerably in recent years. Already in a 1946 study, it was found that 65 per cent of dentists complained of back pain. Even after the evolution to seated four-handed dentistry and ergonomic equipment, studies found back, neck, shoulder or arm pain present in up to 81 per cent of dental operators (Bethany Valachi & Valachi, 2003). Muscular pain is a common affliction which begins when dentists start professional studies. Research has recognized that WMSDs in dentistry considerably contribute to sick leave, reduced productivity and leaving the profession (Hayes, Cockrell, & Smith, 2009).

Musculoskeletal pain, particularly back and neck pain, is a significant occupational health hazard in the dental profession. A Finnish study reports musculoskeletal symptoms from the back and neck of 30% of dentists. In an American survey, 57% of 960 dentists in a Dental Society reported occasional back pain. (Singh Gambhir, 2011). This pain can be attributed to numerous risk factors, including prolonged static postures (PSPs); repetitive movements; suboptimal lighting; poor positioning; genetic predisposition; mental stress; physical conditioning; and age. Dentists frequently assume static postures, which require more than 50 per cent of the body's muscles to contract holding the body motionless while resisting gravity. The static forces resulting from these postures are much more taxing than dynamic (moving) forces (Bethany Valachi & Valachi, 2003). When the human body is subjected repeatedly to PSPs, it can initiate a series of events that may result in pain, injury or a career-ending MSD (Figure 2).

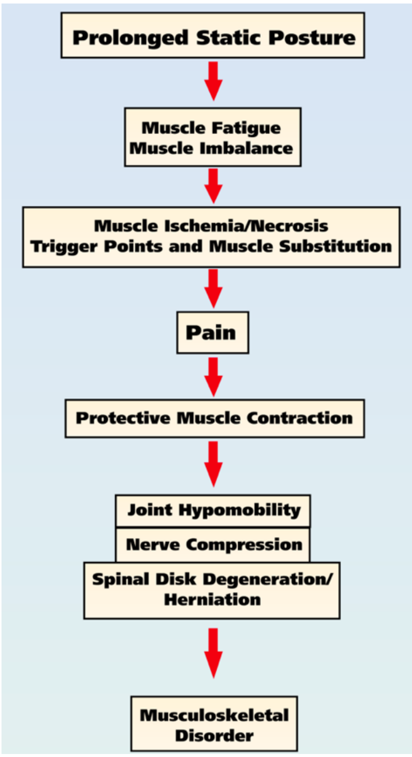
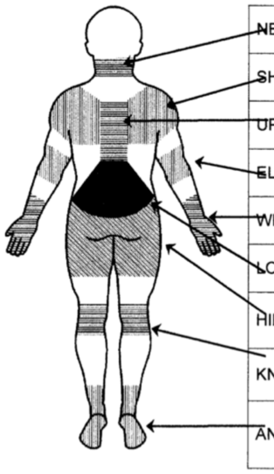


FIGURE 2 FLOWCHART SHOWING HOW PROLONGED STATIC POSTURES CAN PROGRESS TO PAIN OR A MUSCULOSKETETAL DISORDER (Bethany Valachi & Valachi, 2003)

Many studies utilized a modification of the Standardized Nordic Questionnaire as part of their surveys (Kuorinka et al., 1987). The questionnaires consist of structured , forced, binary or multiple-choice variants and can be used as self-administered questionnaires and can also be used in interviews (Figure 3). There are two types of questionnaires: a general questionnaire, and specific ones focusing on the low back and neck/shoulders. The purpose of the general questionnaire is simple surveying, while the specific ones permit a somewhat more profound analysis (Kuorinka et al., 1987).

MUSCULOSKELETAL DISORDERS

Please answer by putting a cross in the appropriate box_ one cross for each question. Please answer every question even if you have never had trouble in any parts of your body. This picture shows how the body has been divided. You should decide for yourself which part (if any) is or has been affected.



	Have you at any time during the last 12 months had trouble (such as ache, pain, discomfort, numbness) in:	During the last 12 months have you been prevented from carrying out normal activities (e.g. job, housework, hobbies) because of this trouble in:	During the last 12 months have you seen a physician for this condition:	During the last 7 days have you had trouble in:
NECK	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
SHOULDERS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
UPPER BACK	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
ELBOWS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
WRISTS/ HANDS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
LOWER BACK	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
HIPS/ THIGHS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
KNEES	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
ANKLES/ FEET	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes

FIGURE 3 PART OF STANDARDIZED NORDIC QUESTIONNAIRE (Kuorinka et al., 1987)

A review used Standardized Nordic Questionnaire for a survey among dental professionals suggests that the prevalence of general musculoskeletal pain ranges between 64% and 93%. The most prevalent regions for pain among dentists are the back (36.3–60.1%) and neck (19.8–85%) (Hayes et al., 2009).

Musculoskeletal pain in dentists was negatively correlated with years of work experience. It has been hypothesized that more experienced dentists learn to adjust their work posture to avoid such problems, or that dentists with musculoskeletal problems have left the profession. It seems essential to include “Posture at the workplace” in the educational university program, to correct student posture immediately and prevent future exposure to WMSDs.

Another critical factor to consider is physical activity. In many studies, investigators concluded that implementing regular physical activity and stretching reduced the frequency of musculoskeletal pain (Roll et al., 2019).

In a recent review (Roll et al., 2019), authors results revealed that insufficient literature is available to suggest conclusively that physical activity benefits dentists in preventing musculoskeletal pain. Because participants in most studies implemented physical exercise after musculoskeletal symptoms were present, there is limited data on the preventive effects of physical activity. However, physical activity and ergonomic training seems to be the best combination to reduce pain of WMSDs, and as an upper limb hard sport, stretching exercise programs have a positive effect on preventing upper extremity musculoskeletal disorders (Luger, Maher, Rieger, & Steinhilber, 2017).

POSTURE IN DENTISTRY

Posture in dentistry is essential to perform all treatments efficiently in a sitting position and reducing the amount of stress in the back, neck and upper limbs. Ideal posture is neutral, and the joints are near the middle of the full range of motion. We have to avoid repetitive motions combined with forceful movements, awkward posture and insufficient recovery time.
The following recommendations are designed to promote proper postural biomechanics for the dental clinician (Ahearn, Sanders, & Turcotte, 2010):

1. The dental clinician should be seated at the appropriate height with the body well stabilized. The dental chair and patient chairs should be adjusted so that the patient's mouth is close to the height of the operator's elbow. In this way the dental clinician to access the oral cavity while minimizing forward flexing of the trunk.

2. The dental clinician chair should stabilize the body in an optimal position to perform dental treatments. Dental clinician chairs should allow for easy height adjustment, a padded seat, support for the back, and options for seat tilt depending on the practitioners' preferences.

3. Patient chairs should enable dental clinicians to get as close to patients as possible. The position of the occlusal line of the maxillary teeth affects the spinal positioning of the clinician. Therefore, the dental clinician should ask the patient change positions by lifting or lowering the chin, and turning the head right to the left, or adjusting the headrest. The operatory space should have ample clearance around the patient's head to allow unimpeded access to the mouth. Dental practitioners are taught to move around the patient's mouth to promote better ergonomic positioning

4. The dental light should be located within an arm's reach of the dental clinician.

5. The dental tray, or delivery system, holds all the dental instruments. The placement of delivery systems can promote correct ergonomic positioning of the body and may vary depending on the office set up and the use of four-handed dentistry. In general, the reach to procure dental instruments should not exceed about 18"–20".

The injury prevention guidelines emphasize an upright posture for the dental clinician, stabilization of the trunk, minimal reach to obtain equipment, close accessibility to the oral cavity, and the ability to change position frequently to improve access.

The Modified-Dental Operator Posture Assessment Instrument (M-DOPAI) is a validated method to evaluate dentist posture quantitatively (Table 4). Authors defined the correct angle degree to avoid dangerous joints position that could lead to the onset of WMSDs (Partido, 2017).

	Acceptable (1 point)	Compromised (2 points)	Harmful (3 points)
Hips	Level on stool; upper thighs parallel; feet flat	Hips not level on stool; upper thighs not parallel; feet crossed, not flat on floor	
Trunk	Front to back <20° Side to side <20° Rotation between planes <20°	Front to back >20°, <45° Side to side >20°, <45° Rotation between planes >20°, <45°	Front to back >45° Side to side >45° Rotation between planes >45°
Head and neck	Front to back <20° Side to side <20° Rotation between planes <20°	Front to back >20°, <45° Side to side >20°, <45° Rotation between planes >20°, <45°	Front to back >45° Side to side >45° Rotation between planes >45°
Upper arms	Upper arms parallel to long axis of torso Elbows at waist level	<20° abduction away from body Elbows at waist level but <60°	>20° abduction away from body Elbows at waist but >60°
Shoulders	Relaxed Both shoulders level with line of trunk	Slumped forward One or both shoulders elevated above line of trunk	
Wrists	Flexion or extension <15° (either wrist)	Flexion or extension >15° (either wrist)	

TABLE 4 CRITERIA OF MODIFIED-DENTAL OPERATOR POSTURE ASSESSMENT INSTRUMENT (Partido, 2017)

In the figure below (Figure 4) is a schematic representation of ideal posture.

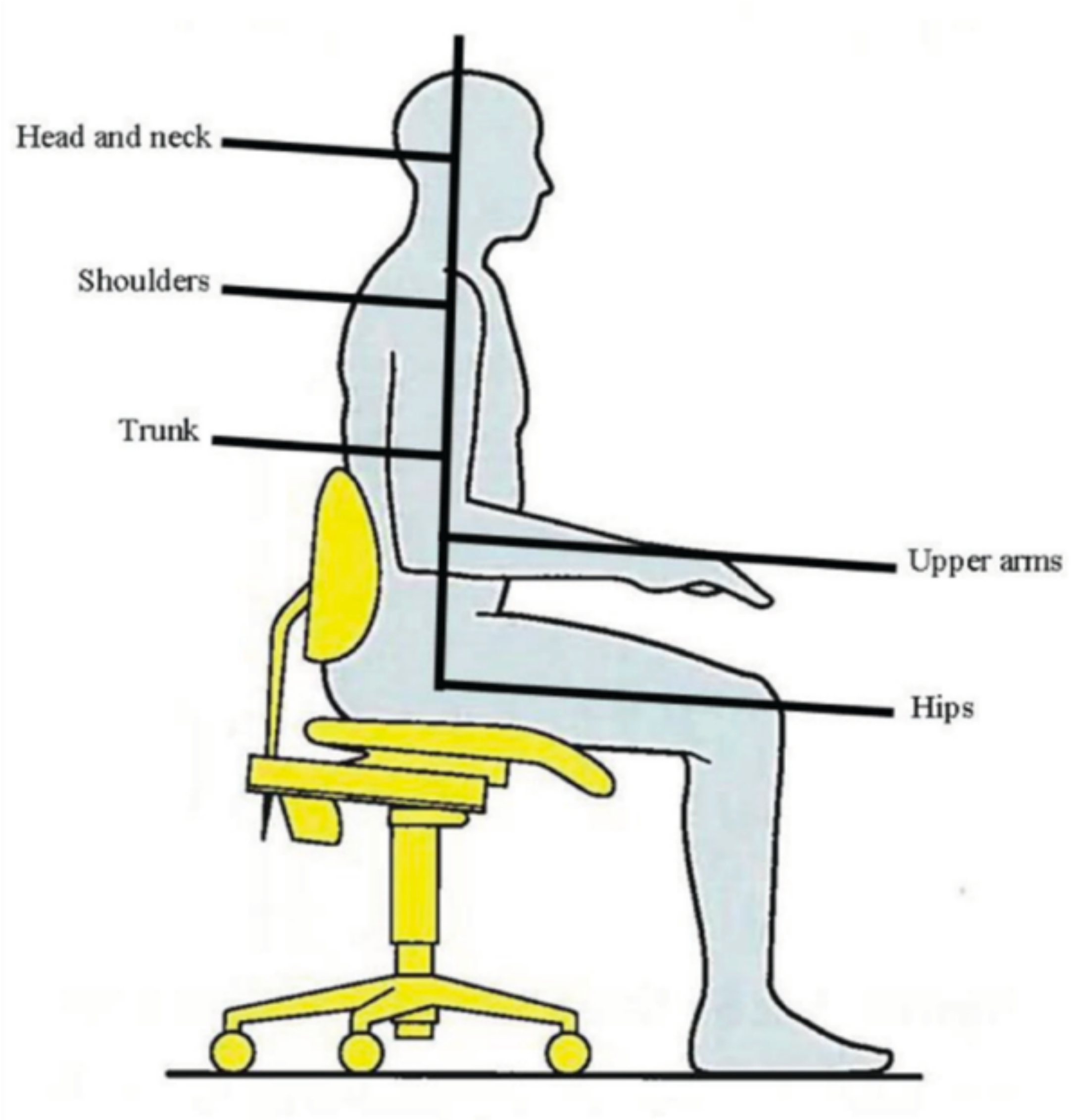


FIGURE 4 IDEAL AND NEUTRAL BODY POSTURE (Partido, 2017)

Research shows that maintaining the low back curve—the lumbar lordosis—when sitting can reduce or prevent low back pain. Tilt the seat angle slightly forward 5 to 15 degrees to increase the low back curve. The use of magnification systems and indirect vision allows operators to maintain healthier postures keeping a safe work distance and also preventing neck pain (Bethany Valachi & Valachi, 2003).

In literature, methods for posture analysis have been proposed, one of the most used is named Rapid Upper Limb Assessment (RULA), a survey method developed for use in ergonomic investigations of workplaces where work related upper limb disorders are reported. RULA is a screening tool that assesses biomechanical and postural loading on the whole body with particular attention to the neck, trunk and upper limbs. Reliability studies have been conducted using RULA on groups of VDU (Visual Display Unit) users and sewing machine operators. A RULA assessment requires little time to complete and the scoring generates an action list which indicate the level of intervention required to reduce the risks of injury due to physical loading on the operator (McAtamney & Corlett, 1993).

THE AIM OF THE PROJECT

The aim of our project is to evaluate the potential of the microscope in dental clinical practice with particular attention to dentist posture.

The primary outcome is the assessment of dentist posture during the extraction of third lower molars depending on whether the operator performs the intervention by the use of the operating microscope, surgical loupes or with the naked eye. Data will be evaluated through the index RULA (rapid upper limb assessment) to define whether there is a change in exposure to the risk of WMSDs (Work-related Muskolo - skeletal - disease).

To obtain the values needed for the posture assessment, we will propose a specific posture analysis tool using fiducial markers. This part of the project was conducted in collaboration with "Dipartimento di Ingegneria Elettronica" of Milan.

A secondary project goal is to analyze post-extraction symptoms and side effects using PoSSe (Postoperative Symptom Severity) scale. We will evaluate the differences in terms of clinical outcomes after extraction of third lower molars depending on whether the interventions are performed by the use of the operating microscope, surgical loupes or naked eye.

Finally, we will present an *in vitro* study to evaluate the use of the operating microscope in removing composite remnants on teeth surfaces during debonding. Also, in this case we will compare the three magnification systems and analyze the clinical outcomes in terms of complete composite removing and damages to the enamel.

POSTURAL ASSESSMENT IN DENTISTRY BASED ON MULTIPLE MARKERS TRACKING

BACKGROUND

Work-related MSDs are among the most frequently reported causes of lost or restricted work time. According to the Bureau of Labor Statistics (BLS) in 2015 (Khanagar et al., 2014), WMSDs cases accounted for 33% of all worker injury and illness cases. Nowadays, Computer Vision has a continuously growing role in many assistive technologies mainly due to low cost, versatility and low invasiveness of modern cameras that together with modern Machine Learning techniques allow us to get detailed information in real-time and effectively. In this study, we describe the results obtained from the analysis of the postural assessment of the dentist during operation based on a multiple markers approach. In particular, we focused our research on how two different visual aids: Surgical Loupes with coaxial illumination (SL) and the Operating Microscope (OM) impact postural ergonomics concerning to the Naked Eye (NE) during interventions. We considered 30 extractions of lower wisdom teeth (3.8 and 4.8). Ten extractions were performed per each considered configuration: 10 with SL, 10 with OM and 10 with NE; 15 of these operations were on the left side (3.8) and 15 on the right. We aimed to track the postural evolution of the dentist's backbone, neck and head during the whole operation. Since the dentist is seated during the entire operation, we focused our analysis on the upper limb, investigating the probability for the dentist of long-term work-related musculoskeletal disorders (McAtamney & Corlett, 1993).

The Rula Method

A well-established set of criteria to evaluate upper limb posture during working activity is denominated the RULA (Rapid Upper Limb Assessment). The RULA approach uses diagrams of upper body posture and three scoring tables to provide an evaluation of the exposure to risk factors. The risk factors considered in the complete formulation of the pioneering work of McPhee (McAtamney & Corlett, 1993) are:

- number of movements,
- static muscle work,
- force,
- work postures determined by the equipment and furniture,
- time worked without a break.

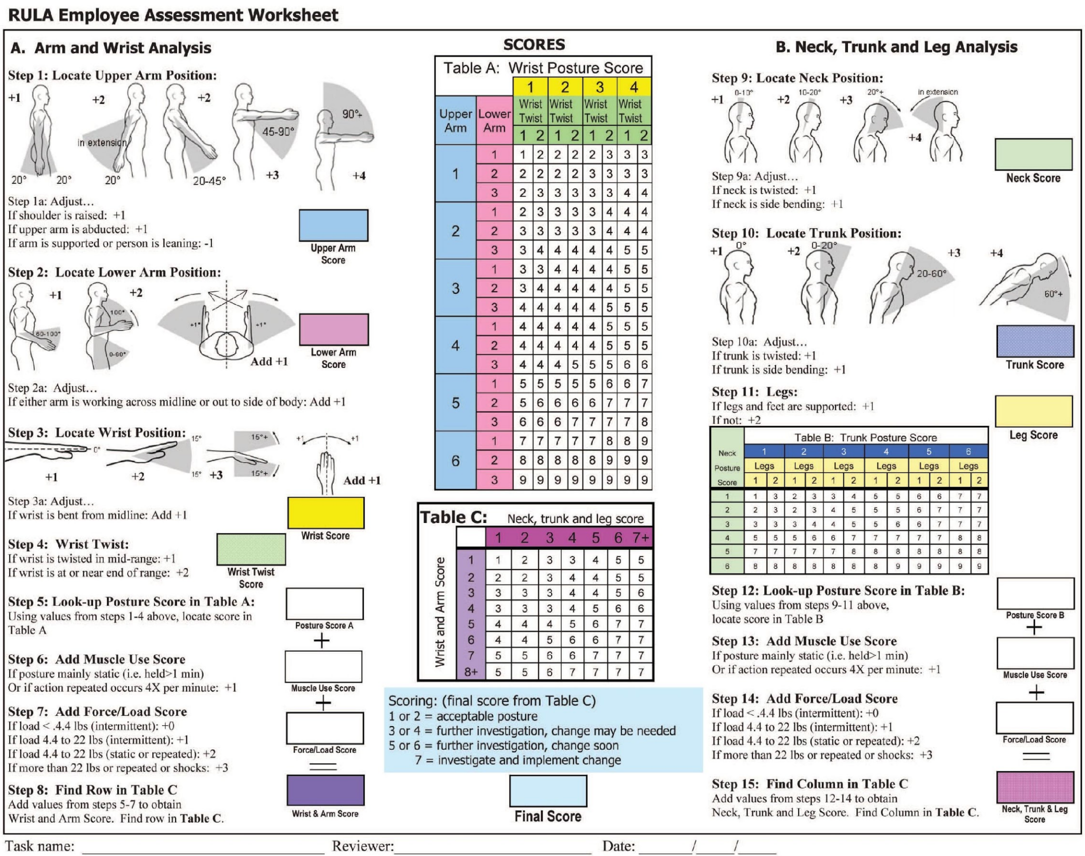
which represent the *external load factors*. McPhee also introduced additional elements which influence the load and that vary between individuals:

- the work posture adopted,
- unnecessary static muscle contraction.
- speed and accuracy of movements,
- duration of pauses taken by the worker.

Some further aspects, related to the *individual's response*, are identified by McPhee as *corrective load factors*, he, in particular, identified:

- age,
- experience,
- workplace environmental factors
- psychological variables.

However, according to a study published in 1994 (A. Aaras, 1994) the *external load factors* are the most relevant in terms of risks for long term WMSDs. The RULA method was designed in order to perform a rapid evaluation without the need of special equipment providing the opportunity for a number of investigators to be trained in doing the assessments without additional equipment expenditure but just a clipboard and a pen; RULA was specifically designed for the urgent requirement of the UK Government issued with the UK Guidelines on the prevention of work-related upper limb disorders under the Health and Safety at Work Etc. Act (Hse, 2003). In Figure 5 a typical RULA Worksheet is reported; different scores are attributed to various aspects like angles between limbs, duration of static postures, values of applied force or moved load.



RULA Employee Assessment Worksheet

A. Arm and Wrist Analysis

Step 1: Locate Upper Arm Position:
+1 20° 20° | +2 in extension 20° | +2 20-45° | +3 45-90° | +4 90°+

Step 1a: Adjust…
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Upper Arm Score

Step 2: Locate Lower Arm Position:
+1 60-100° | +2 100° 0-60° | +1° +1° Add +1

Lower Arm Score

Step 2a: Adjust…
If either arm is working across midline or out to side of body: Add +1

Step 3: Locate Wrist Position:
+1 0° | +2 15° 15° | +3 15°+ 15°+ | +1 +1 Add +1

Step 3a: Adjust…
If wrist is bent from midline: Add +1

Wrist Score

Step 4: Wrist Twist:
If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

Wrist Twist Score

Step 5: Look-up Posture Score in Table A:
Using values from steps 1-4 above, locate score in Table A

Posture Score A
+

Step 6: Add Muscle Use Score
If posture mainly static (i.e. held>1 min)
Or if action repeated occurs 4X per minute: +1

Muscle Use Score
+

Step 7: Add Force/Load Score
If load < .4.4 lbs (intermittent): +0
If load 4.4 to 22 lbs (intermittent): +1
If load 4.4 to 22 lbs (static or repeated): +2
If more than 22 lbs or repeated or shocks: +3

Force/Load Score
=

Step 8: Find Row in Table C
Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in **Table C**.

Wrist & Arm Score

SCORES

Table A: Wrist Posture Score

Upper Arm	Lower Arm	1 Wrist Twist 1	1 Wrist Twist 2	2 Wrist Twist 1	2 Wrist Twist 2	3 Wrist Twist 1	3 Wrist Twist 2	4 Wrist Twist 1	4 Wrist Twist 2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table C: Neck, trunk and leg score

Wrist and Arm Score	1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Scoring: (final score from Table C)
1 or 2 = acceptable posture
3 or 4 = further investigation, change may be needed
5 or 6 = further investigation, change soon
7 = investigate and implement change

Final Score

B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:
+1 0-10° | +2 10-20° | +3 20°+ | +4 in extension

Step 9a: Adjust…
If neck is twisted: +1
If neck is side bending: +1

Neck Score

Step 10: Locate Trunk Position:
+1 0° | +2 0-20° | +3 20-60° | +4 60°+

Step 10a: Adjust…
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score

Step 11: Legs:
If legs and feet are supported: +1
If not: +2

Leg Score

Table B: Trunk Posture Score

Neck Posture Score	1 Legs 1	1 Legs 2	2 Legs 1	2 Legs 2	3 Legs 1	3 Legs 2	4 Legs 1	4 Legs 2	5 Legs 1	5 Legs 2	6 Legs 1	6 Legs 2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Step 12: Look-up Posture Score in Table B:
Using values from steps 9-11 above, locate score in Table B

Posture Score B
+

Step 13: Add Muscle Use Score
If posture mainly static (i.e. held>1 min)
Or if action repeated occurs 4X per minute: +1

Muscle Use Score
+

Step 14: Add Force/Load Score
If load < .4.4 lbs (intermittent): +0
If load 4.4 to 22 lbs (intermittent): +1
If load 4.4 to 22 lbs (static or repeated): +2
If more than 22 lbs or repeated or shocks: +3

Force/Load Score
=

Step 15: Find Column in Table C
Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in **Table C**.

Neck, Trunk & Leg Score

Task name: ______________________ Reviewer: ______________________ Date: ____/____/____

FIGURE 5 RULA EMPLOYEE ASSESSMENT WORKSHEET

Even if the RULA method is one of the most commonly used in industrial environments, its results are based on the subjective evaluation of angles and postures performed by an investigator from a direct observation or a movie. Some other approaches have then been proposed in order to improve RULA accuracy. A set of them is based on integrated graphic design tools, where a digital human model (DHM) is integrated with the 3D product-process design environment; NERPA (Novel Ergonomic Postural Assessment Method) is an example (Sanchez-Lite, Garcia, Domingo, & Sebastian, 2013): based on a complete 3D CAD simulation, it synthesizes the activity sequence in a virtual environment, addressing the functional performance of the parts. This approach is based on the theory of Chaffin (Bakhadher, Halawany, Talic, Abraham, & Jacob, 2015) that affirms that introducing digital human models that enable the study of product and process adaptation for people without any need of physical prototypes can reduce the development time and cost. The effectiveness of this approach was then confirmed by successive studies (Määttä, 2007), (Kurillo et al., 2012). However, apart from different analysis methodologies, the RULA criteria and parameters are the most extensive adopted ergonomics technique. Using the RULA worksheet, the evaluator will assign a score for each of the following body regions: upper arm, lower arm, wrist, neck, trunk, and legs. After the data for each region is collected and scored, tables on the form are then used to compile the risk factor variables, generating a single score that represents the level of MSD risk as outlined in Table 5.

Score	Level of MSD Risk
1-2	negligible risk, no action required
3-4	low risk, change may be needed
5-6	medium risk, further investigation, change soon
6+	very high risk, implement change now

TABLE 5 WMSDS RICK LEVELS ACCORDING TO THE RULA WORKSHEET DATA

The proposed approach

In our specific analysis, we are considering the activity of a dentist during a dental operation. In this case no load transfer or wide and rapid motions are involved, and the main issues are related to static postures. If we consider the RULA Assessment Worksheet in Figure 6 the most relevant postural issues are related to: frontal rotation, twisting and side bending of the neck and of the trunk. Furthermore, during the operation, dentists usually held a static position for a long period ($> 1min$) which, according to RULA Worksheet, represents a further risk element. In order to evaluate the dentist posture accurately and objectively , we applied a set of markers on the back of a tight T-shirt worn by the dentist during the whole operation that was acquired using a 5 MPixels Gigabit ethernet camera. In Figure 6 it is possible to see the location of different markers on the back of the T-shirt and the scrub hat.

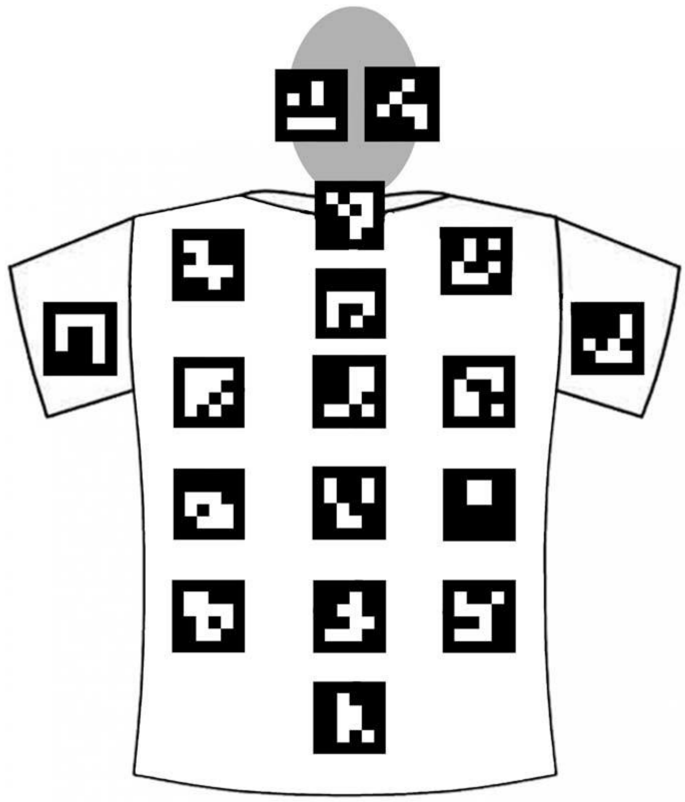


FIGURE 6 A PICTORIAL REPRESENTATION OF THE BACK OF THE T-SHIRT WORN BY THE DENTIST DURING THE OPERATION.

In literature, there are several fiducial marker systems proposed; those based on square markers have gained popularity, especially in the augmented reality community (Fiala, 2010) (Kato & Billinghurst, 1999). The main reason is related to the opportunity of extracting the camera pose from their four corners, given that the camera is calibrated correctly. In most of the approaches, markers encode a unique identification code by a binary code that may include error detection and correction bits (Dell'Acqua, Ferrari, Marcon, Sarti, & Tubaro, 2005). In general, each author has proposed its own predefined set of markers (dictionary) since the number of required markers varies among different applications and, accordingly, the dictionary size. Furthermore, if the number of necessary markers is small, then a small dictionary with a large inter-marker distance is desirable in order to increase the error rejection in noisy acquisitions. Analyzing different solutions available from literature, we chose the method proposed in Figure 7 since it fulfills the constraints mentioned above and is also robust to partial occlusions. Below it is possible to see three examples of markers extracted from dictionaries with different sizes.

FIGURE 7 THREE EXAMPLES OF ARUCO FIDUCIAL MARKERS MADE (FROM LEFT TO RIGHT) OF 5 × 5, 6 × 6, 8 × 8 BITS

The advantages of such an approach with respect to typical Motion Capture (MoCap) systems, e.g. (Schwartz & Rozumalski, 2005) (Shiratori, Park, Sigal, Sheikh, & Hodgins, 2011) (Tranberg, 2010) consist in the absence of powered and/or heavy and cumbersome markers like wearable cameras or accelerometers. Furthermore, every single marker provides much more information concerning approaches based on simple reflective markers because for every marker we can accurately estimate its distance from the camera and its spatial orientation, providing us with an estimation of the tangent plane in the marker region. In Figure 8 we show an acquisition of the dentist's back during operation. Here, two additional markers are placed on the surgical cap to estimate head backbone angle and two markers are placed on the stool to provide a reference of the whole-body motion during the operation.

FIGURE 8 A FRAME OF THE DENTIST'S BACK DURING OPERATION

In Figure 9 all the markers on the back are recognized and adequately localized. The reference system of each of them with the *x*, *y*, and *z* axes are represented by the red, green and blue segments respectively.

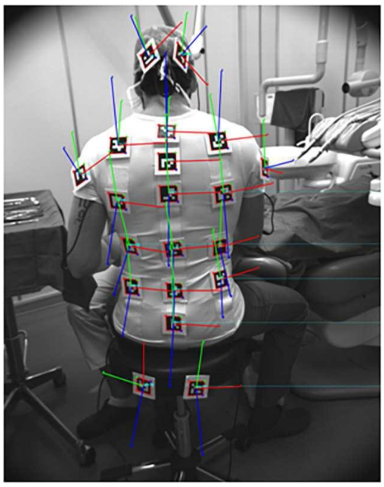


FIGURE 9 MARKERS RECOGNIZED AND 3D AXES SET DEPICTED ON THE IMAGE

The global reference system

Since, in the RULA and other evaluation methods the gravity and angles of different limbs concerning the vertical direction play a crucial role, it's fundamental that all our measures are referred to a global reference system, whose *z*-axis is aligned to the gravity. In order to achieve this, we acquired a checkerboard on the floor (or placed on a plane parallel to the floor) and assumed its reference system as the global one. In Figure 10 we show the acquisition of the global reference system with the axes superimposed.

FIGURE 10 THE GLOBAL REFERENCE SYSTEM DEFINITION BASED ON A CHECKERBOARD PLACED PARALLEL TO THE GROUND. THE RED AND GREEN AXES (X AND Y RESPECTIVELY) REPRESENT THE GROUND PLANE WHILE THE BLUE SEGMENT REPRESENTS THE Z VERTICAL AXIS.

All the 3D markers are then turned into this reference system: calling $\mathbf{t}m$ and $\mathbf{R}m$ the translation vector and the rotation matrix of each marker with respect to the camera frame, and defining $\mathbf{t}c$ and $\mathbf{R}c$ the translation vector and the rotation matrix of the reference checkerboard with respect to the camera frame. We can define a global transformation as evidenced by Figure 11.

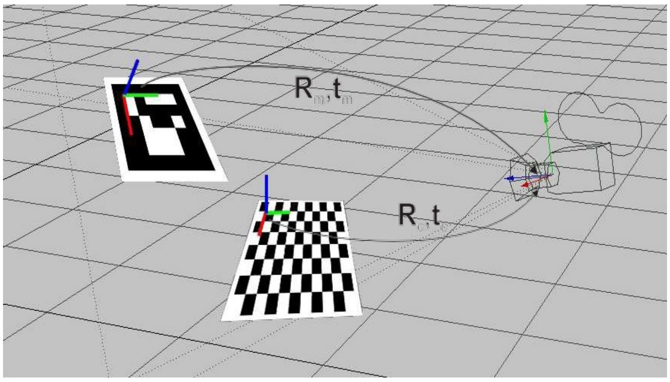


FIGURE 11 THE THREE CONSIDERED REFERENCE SYSTEMS: ONE OF THE ARUCO MARKER, ONE OF THE CAMERA AND ONE OF THE CHECKERBOARD. TM AND RM REPRESENT THE TRANSLATION AND ROTATION FROM THE MARKER TO THE CAMERA SYSTEM, WHILE TC AND RC ARE THE TRANSLATION AND ROTATION FROM THE CHECKERBOARD TO THE CAMERA SYSTEM.

In order to transform all the points into the checkerboard global reference frame, we can apply the following considerations: A 3D point in homogeneous coordinates, $X = [\, x \ y \ z \ 1]^T$, can be transformed from the marker reference system into the camera reference system through equation 1

$$X_{cam} = \begin{bmatrix} & \mathbf{R}_m & & \mathbf{t}_m \\ 0 & 0 & 0 & 1 \end{bmatrix} X = T_{cam} X$$

EQUATION 1

analogously, moving from the checkerboard to the camera reference system can be done through a transformation *Tcheck*

$$T_{check} = \begin{bmatrix} & \mathbf{R}_c & & \mathbf{t}_c \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

EQUATION 2

The whole transform can then be obtained as:

$$X_{check} = T_{check}{}^{-1} T_{cam} X = \begin{bmatrix} & \mathbf{R}_c & & \mathbf{t}_c \\ 0 & 0 & 0 & 1 \end{bmatrix}^{-1} \begin{bmatrix} & \mathbf{R}_m & & \mathbf{t}_m \\ 0 & 0 & 0 & 1 \end{bmatrix} X$$

$$= \begin{bmatrix} & \mathbf{R}_c{}^T & & -\mathbf{R}_c{}^T \mathbf{t}_c \\ 0 & 0 & 0 & 1 \end{bmatrix}^{-1} \begin{bmatrix} & \mathbf{R}_m & & \mathbf{t}_m \\ 0 & 0 & 0 & 1 \end{bmatrix} X$$

EQUATION 3

Applying this transformation to all the markers in all the acquired frames (**Rm** and **tm** change according to different markers and different frames) we are able to track the evolution of the position and orientation of all the markers in a global reference frame where the *z−axis* is parallel to the gravity vector: This is important since many of the RULA parameters evaluate limb orientation with respect to the gravity vector. Following the proposed approach, we do not have any constraint on the camera that can be placed in a suitable position and orientation to frame the whole operative scene without interfering with ongoing activities.

In Figure 12 we show three simple motion history representations where at every frame the previous markers positions are overlaid with the new one. Such a representation provides a pictorial representation of what is the dentist's postural evolution while the analysis that we performed is based on a 3D model associated with each marker position. In Figure 14, we provide a representation of our model and in Figure 15 the 3D model is extracted from a single frame: every marker is recognized and the reference system is rotated in order to assign the vertical axis parallel to the gravity while the z-axes of each marker (represented by the orange segments) represent the normal to the considered sur- face. Since most of WMSDs reported in dentistry concern the back, neck and shoulders, we focused our analysis on the following parameters:

- the neck position with respect to the trunk,
- the trunk orientation with respect to the vertical axis,
- the upper arm orientation with respect to the trunk,
- the twist and bending of the neck and back ,
- the overall static position of the aforementioned limbs.

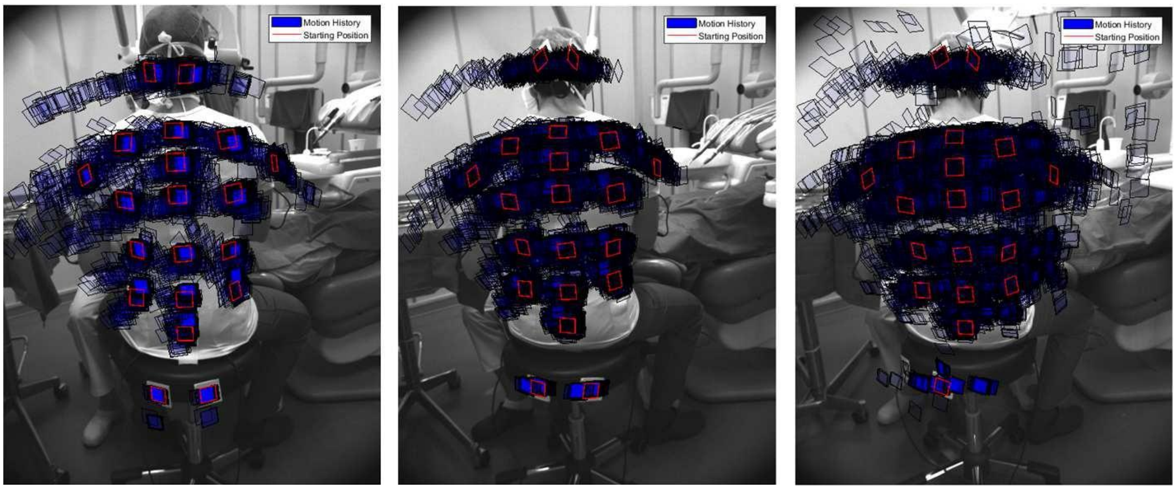


FIGURE 12 A SIMPLE MOTION HISTORY REPRESENTATION WHERE THE POSITION OF EACH MARKER IS SIMPLY OVERLAID TO THE PREVIOUS ONES. ON THE LEFT AN OPERATION WITH THE OM, AT THE CENTER ONE WITH THE SL WHILE ON THE RIGHT AN OPERATION WITH NE. IT CAN BE SEEN THE INCREASING AVERAGE MOTION FROM LEFT TO RIGHT IMAGE.

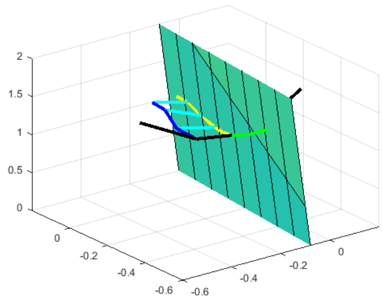


FIGURE 13 A REPRESENTATION OF THE SAGITTAL PLANE EXTRACTED FROM THE SPINE MARKERS

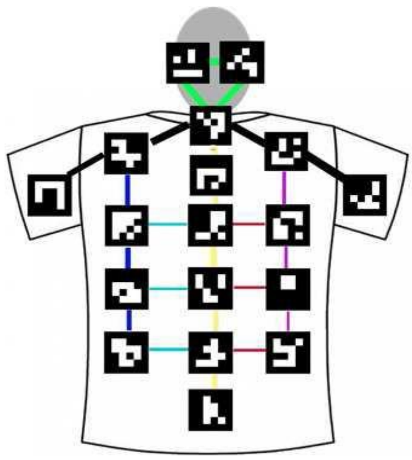


FIGURE 14 MODEL THAT WE ADOPTED IN OUR ANALYSIS BASED ON THE MARKERS POSITIONS

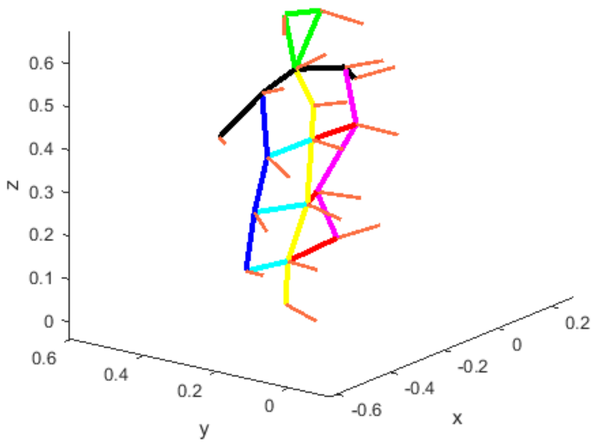


FIGURE 15 THE 3D MODEL EXTRACTED FROM ONE FRAME. THE ORANGE SEGMENTS REPRESENT THE SURFACE NORMALS, I.E. THE *Z* AXIS OF EVERY MARKER.

Analyzing the neck angle, in order to remove twisting and side bending components we projected all the markers positions in the sagittal plane. The sagittal plane is obtained by analyzing the covariance matrix of the positions of the spine markers; following the Principal Component Analysis (Sigilião, Marquezan, Elias, Ruellas, & Sant'Anna, 2015) (Pearson, 1901) the eigenvector associated with the smallest eigenvalue represents a vector normal to the sagittal plane. In Figure 13 the sagittal plane is represented where we project spine, neck and head markers in order to estimate postural angles with respect to the sagittal plane. Once angles in this plane are evaluated the twist angles can be estimated analyzing out of plane rotations: in particular the twist can be evaluated analyzing the rotation along the eigenvector associated to the highest eigenvalue and side bending can be associated to the rotation along the remaining eigenvector (associated to the mean eigenvalue). In the following section we will focus on the angles in the sagittal plane.

RESULTS

As indicated above we analyzed 3 different configurations: naked eyes (NE), Surgical Loupes (SL) and the Operating Microscope (OM).

In the following section we describe the procedure in order to monitor the neck-spine rotation: the angle in the sagittal plane is analyzed in the three aforementioned configurations, for operations on the right side of the mouth and the results are reported in Figure 16.

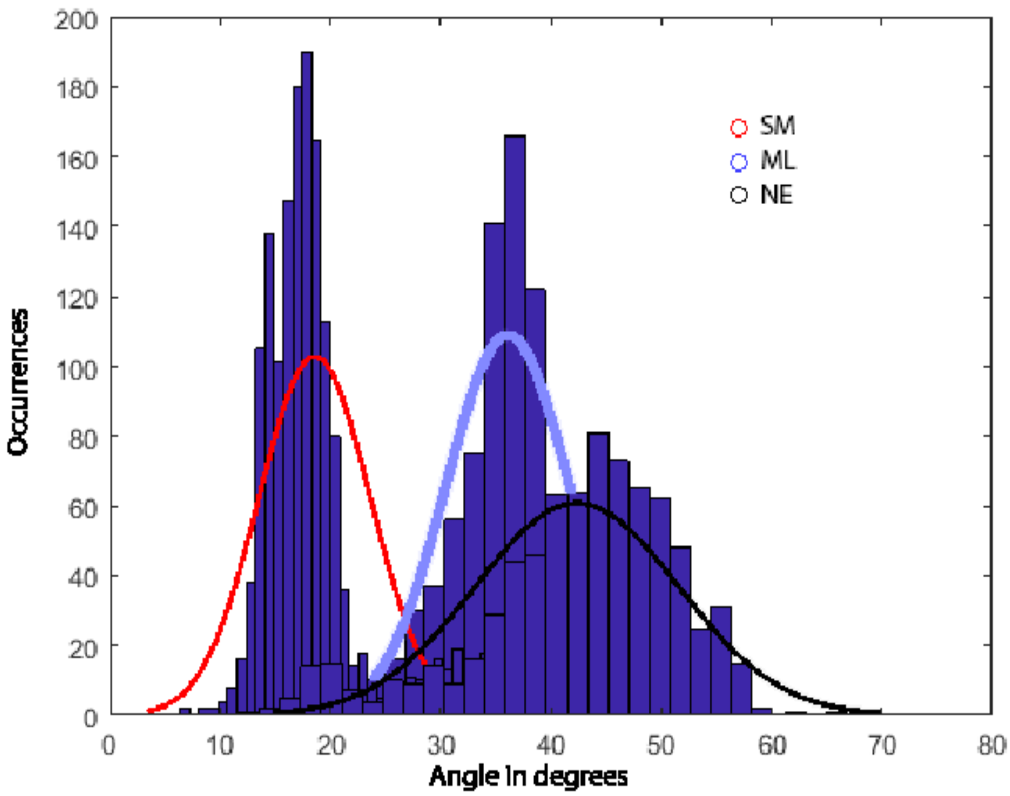


FIGURE 16 SUPERPOSITION OF THE THREE HISTOGRAMS REPRESENTING NECK-SPINE ANGLES IN DIFFERENT OPERATIONS CONFIGURATIONS AND THE RELATIVE GAUSSIAN FITTING. THE CONSIDERED OPERATIONS ARE ON THE RIGHT SIDE OF THE MOUTH. THE RED GAUSSIAN REPRESENTS OPERATIONS WITH THE OPERATING MICROSCOPE, THE BLUE REPRESENTS OPERATIONS WITH THE SURGICAL LOUPES AND THE BLACK REPRESENTS OPERATIONS WITH NAKED EYE.

In this figure we superposed the three histograms representing the occurrences of different neck angles during OM, SL and NE configurations for each of them we analyzed 5 operations on the right side of the mouth. The same analysis, performed on the left side of the mouth , is reported in Figure 17.

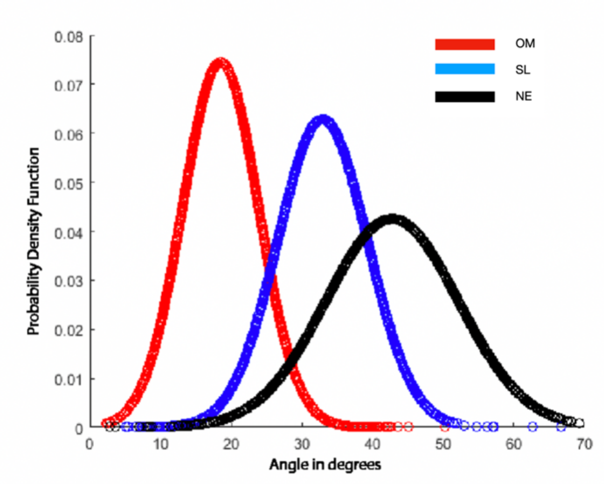


FIGURE 17 DISTRIBUTIONS OF THE NECK ROTATION WITH RESPECT TO THE SPINE IN THE SAGITTAL PLANE FITTED WITH A GAUSSIAN DISTRIBUTION. THE CONSIDERED OPERATION ARE ON THE LEFT SIDE OF THE MOUTH. THE SM INVOLVES A MUCH LOWER AVERAGE ANGLE WITH RESPECT TO ML THAT IS STILL LOWER THAN THE ONE OF THE SL AND NE, INDICATING A MORE STABLE CONFIGURATION

As evidenced from these results, it is clear that the average neck frontal bending when using the OM is lower (more than 20°) with respect to the SL and much lower (about 27°) with respect to the NE.

DISCUSSION

In this chapter, we presented a novel approach for the upper limb posture assessment based on the tracking of a set of planar markers placed on the clothes of the worker. Thanks to this non-invasive approach, we were able to follow the 3D position and orientation of all the limbs involved in a specific activity during the job execution. The analysis that we performed can be easily integrated into classical ergonomics assessment tools like RULA or NERPA providing an objective methodology that does not involve an operator in a subjective interpretation of the monitored job. We applied the proposed approach on operative dentistry comparing the postural impact of different tools used to perform the same operations: extraction of lower wisdom teeth using an Operating Microscope, Surgical Loupes or only the Naked Eye. Thanks to our analysis we found that the use of the operating microscope greatly reduces the neck frontal bending and the overall angle between the head and the spine with respect to the naked eye operation, while the surgical loupes were placed in between the microscope and naked eye. According to ergonomics assessment tools mentioned above we demonstrated that the usage of the microscope might have a significant impact in the reduction of exposure to the risk of long term Musculoskeletal disorders, at least in the neck-spine regions. We believe that the presented approach can find useful applications in many other fields of ergonomics providing the investigator with an objective and useful tool to assess postures of different jobs.

THE USE OF MAGNIFYING SYSTEMS FOR THE EXTRACTION OF LOWER THIRD MOLARS

BACKGROUND

Third lower molar extraction: pre-intervention evaluations

The extraction of lower third molars is one of the most common and widespread intervention in oral surgery (Ruta, 2000). It is a surgical procedure of relatively limited invasivity, which can, therefore, weaken the patient after the operation, and lead to pain, swelling, hematoma, trismus, dry socket, fever and surgical wound infection and other complications. They are unpleasant for patients and could generate difficulty in chewing, speaking, performing oral hygiene, and alteration of other activities of daily living, resulting in days off from work or study (Grossi et al., 2007). The surgeon needs to be able to manage all the problems during and after the interventions. Therefore the preclinical phase of planning is essential, where you analyze the patient, the mouth, teeth and all the radiographs of the patient.

Indications for extraction of third lower molars have always been a topic of debate in the scientific-dental world. If there is a clear need for intervention in case of signs and symptoms of illness, therapeutic protocols concerning the extraction of asymptomatic third molars without clinical-pathological signs remain debated. Currently, the indications for extraction are the presence of painful symptoms, pulpitis, pericoronitis, periodontal defects, caries and all the conditions that can affect the health of the second adjacent molar. In addition, we can have orthodontic or prosthetic indications for extraction, in particular when the position of the wisdom tooth impedes dental movements or realization of prosthetic rehabilitation

(Steed, 2014). There is no scientific evidence regarding the preventive extraction of asymptomatic third molars without clinical or radiographic pathological signs. In this case, it is advisable to monitor the asymptomatic wisdom teeth over time to prevent the onset of pathology or to take action quickly (Ghaeminia et al., 2016). The British clinical recommendations of the National Institute for Health and Care Excellence also state that preventive extraction of third molars should be discouraged, the presence of plaque around the third molar should be seen as a risk factor but not as an indication itself for the extraction. Furthermore, a single episode of pericoronitis is not enough to justify the extraction procedure (NICE, 2000).

In order to assess the difficulty of extraction, the degree of inclusion is a relevant issue (Akadiri & Obiechina, 2009). It is important to know the depth and spatial orientation of the wisdom tooth in relation to the mandible and other teeth.

Two classifications based on radiographic examinations have been proposed.

Winter classification (Figure 18): based on the inclination of the impacted wisdom tooth (*3rd molar*) to the long axis of the *2nd molar* (Winter 1926).

Pell and Gregory classification (Figure 19): based on the relationship between the impacted lower wisdom tooth (3^{rd} molar) to the *ramus of the mandible* (lower jaw) and the 2nd molar (based on the space available *distal* to the 2nd molar), (Pell and Gregory 1933).

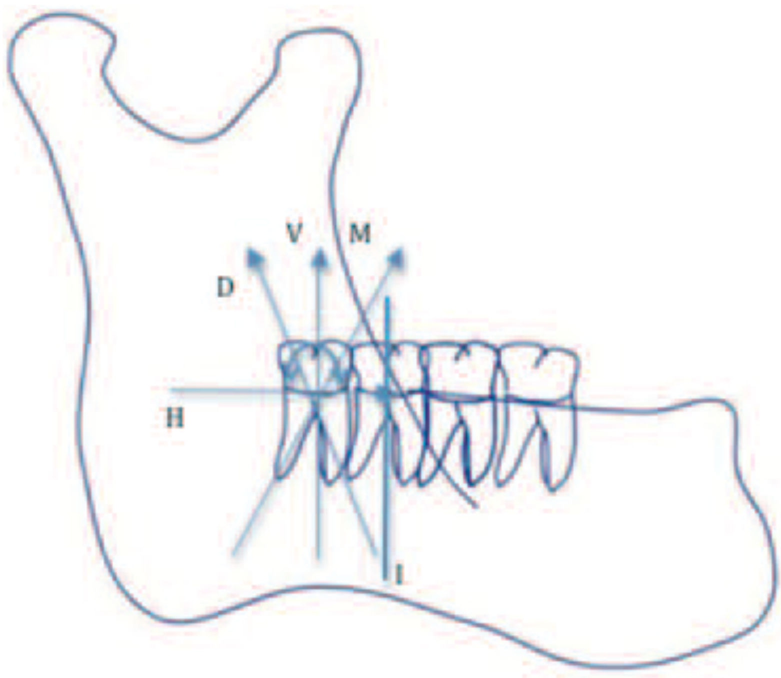


FIGURE 18 WINTER CLASSIFICATION

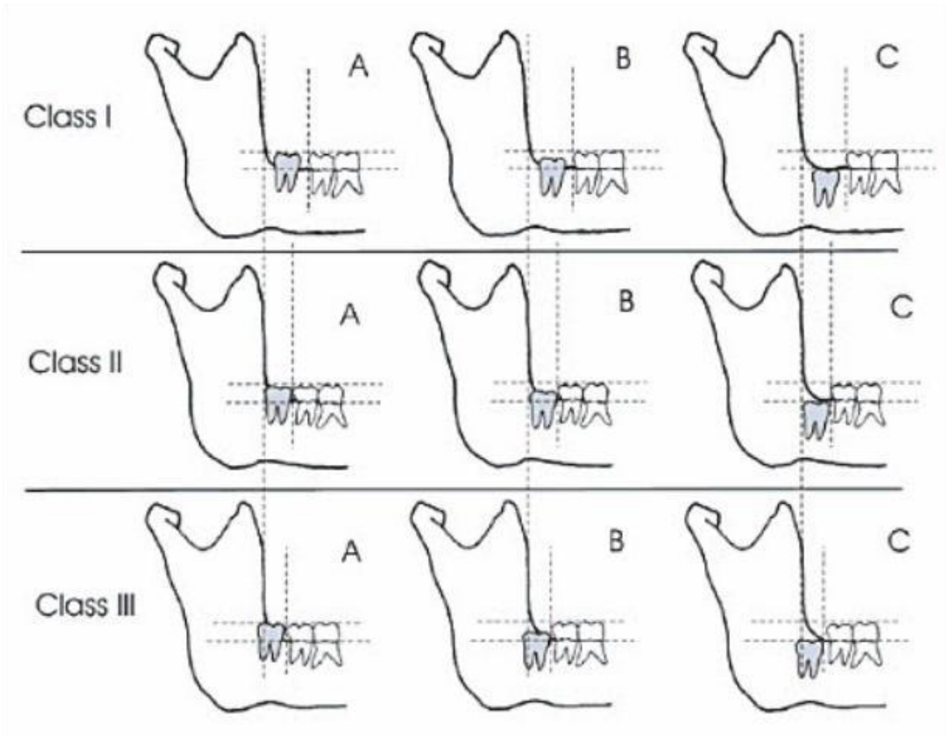


FIGURE 19 PELL AND GREGORY CLASSIFICATION

In recent years was proposed a new mandibular third molar impaction and extraction difficulty degree classification (Table 6 Juodzbalys and Daugela 2013 Mandibular third molar impaction classification) based on anatomical and radiologic findings and literature review results (Juodzbalys & Daugela, 2013).

Position of the mandibular third molar	Risk degree of presumptive intervention (score)			
	Conventional (0)	**Simple (1)**	**Moderate (2)**	**Complicated (3)**
Mesiodistal position in relation to the second molar – M and the mandibular ramus – R				
Relation to the second molar - M	Crown directed at or above the equator of the second molar	Crown directed below the equator to the coronal third of the second molar root	Crown/roots directed to the middle third of the second molar root	Crown/roots directed to the apical third of the second molar root
Relation to the mandibular ramus – R	Sufficient space in the dental arch	Partially impacted in the ramus	Completely impacted in the ramus	Completely impacted in the ramus in distoangular or horizontal position
Apicocoronal position in relation to the alveolar crest – A and the mandibular canal – C (IAN injury risk)				
Relation to the adjacent alveolar crest (from the uppermost point of the tooth) - A	Tooth is completely erupted	Partially impacted, but widest part of the crown (equator) is above the bone	Partially impacted, but widest part of the crown (equator) is below the bone	Completely encased in the bone
Relation to the mandibular canal (from the lowermost point of the tooth) - C	≥ 3 mm to the mandibular canal	Contacting or penetrating the mandibular canal, wall of the mandibular canal may be identified	Contacting or penetrating the mandibular canal, wall of the mandibular canal is unidentified	Roots surrounding the mandibular canal
Buccolingual position in relation to mandibular lingual and buccal walls – B (LN injury risk)				
Relation to mandibular lingual and buccal walls – B	Closer to buccal wall	In the middle between lingual and buccal walls	Closer to lingual wall	Closer to lingual wall, when the tooth is partially impacted or completely encased in the bone (A2 or A3)
Spatial position - S				
Spatial position - S	Vertical (90°)	Mesioangular ≤ 60°	Distoangular ≥ 120°	Horizontal (0°) or inverted (270°)

IAN = inferior alveolar nerve; LN = lingual nerve.

TABLE 6 JUODZBALYS AND DAUGELA 2013 MANDIBULAR THIRD MOLAR IMPACTION CLASSIFICATION

The third lower molar is close to critical structures such as the IAN, lingual nerve, and adjacent second molar. The deeper the inclusion, the harder it is to extract it, and more complications may occur during the operation or postoperatively. Among them, injury of the inferior alveolar nerve (IAN) is of most concern for surgeons (Sarikov & Juodzbalys, 2014). The IAN neuropathy related to third lower molar surgery with a reported incidence of 1 - 20% temporary and 0 - 2% permanent. The factors associated with a significantly higher incidence of neuropathy include patients older than 24 years, with horizontal impactions, close radiographic proximity to the mandibular canal, and treatment by inexperienced surgeons (Sarikov & Juodzbalys, 2014).

Another important issue is the risk of infection after extracting wisdom teeth from healthy young people. The incidence of infection is about 10%, and it may be up to 25% in patients who are already sick or have low immunity. Treatment of these infections is generally simple and involves patients receiving antibiotics and drainage of infection from the wound.

On the basis of the results of systematic review (Lodi, Sardella, Bez, Demarosi, & Carrassi, 2013) the use of prophylactic antibiotics will reduce infection to a mean of 3%, which means that approximately 12 (range 10 to 17) people would need to receive antibiotic prophylaxis to prevent one infection.

Patients at a higher risk of infection are more likely to benefit from prophylactic antibiotics, because infections in this group are likely to be more frequent, associated with complications and can be more of a challenge to treat. Due to the increasing prevalence of bacteria which are resistant to treatment by currently available antibiotics, clinicians should consider carefully whether treating 12 healthy patients with antibiotics to prevent one infection is likely to do more harm than good (Lodi et al., 2013).

From the above, extraction of the third lower molar is a safe minor intervention of oral surgery, with a low rate of intraoperative complications in particular for interventions performed by expert surgeons.

Third molar lower molar extraction: surgical procedure

The extraction of the third lower molar is a surgical intervention with a lot of variables highly dependent on the tooth, patient and surgeon experience. The correct evaluation of extraction difficulty as mentioned above is essential, as well as the patient collaboration in terms of adequate opening of the mouth for as long as required (usually from 10-15 min to 1 hour).

The surgical approach to extraction is the same in almost all cases (Figure 20, Figure 21). After a loco-regional anesthesia of the inferior alveolar nerve the incision is performed intrasulcular starting mesial to the second molar. A vertical release is made posterior to the second molar on mandibular ramus (1,5 – 2cm length), and a full-thickness mucoperiosteal flap is elevated. Depending on the depth of inclusion and several other factors, the surgeon could necessitate an extension of the flap to extract the tooth. Therefore the incision can be performed mesial to the first lower molar or second premolar, otherwise mesial releasing incisions may also carry out to obtain the same results. An adequate lingual flap was raised, and a lingual retractor was placed to protect the lingual nerve and the soft tissue that surrounds it.

Once the flap is elevated, vestibular osteotomy is made with rotary instruments (or piezoelectric instruments). The crown of the tooth was removed by coronectomy and to control the direction of roots dislocation, a narrow groove perpendicular to the long axis of the roots was prepared, which began 2–3 mm apical to the remnant cervical margin on the distal surface of the lower third molar, and deeply to the root bifurcation. The roots can be separated (if necessary) and then extracted. The curettage and irrigation of alveolus is made and suture points are positioned. The patient should compress the extraction site by biting onto a gauze swab applied to the socket for 15–20 minutes. This is enough to stop normal post-extraction bleeding. After seven days, in the follow-up appointment, the stitches are removed.

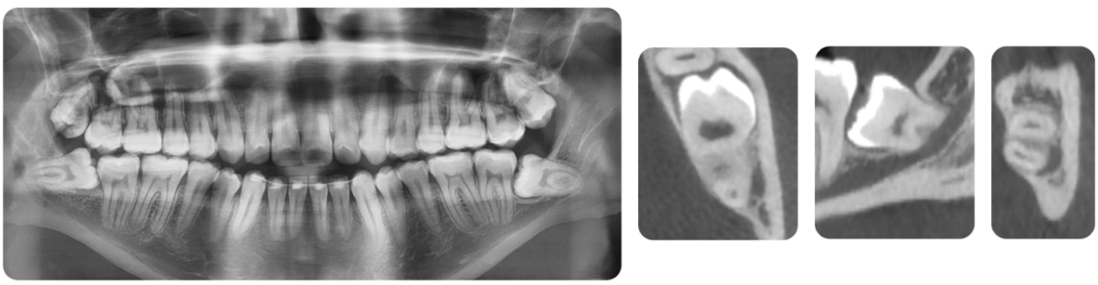


FIGURE 20 RADIOGRAPHS EVALUATION OF 3.8 THIRD LOWER MOLAR

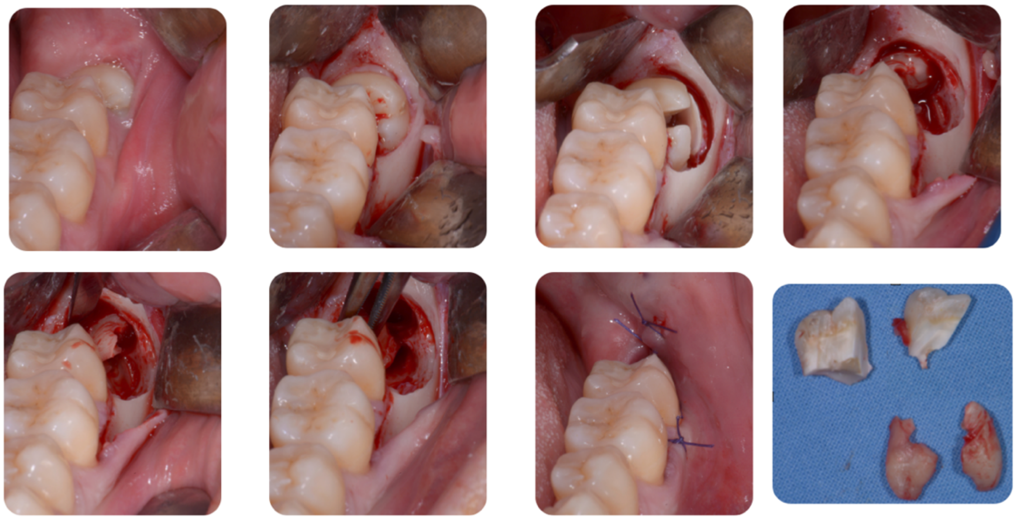


FIGURE 21 EXTRACTION SURGICAL PROCEDURE

The Postoperative Symptom Severity (PoSSe scale)

Several factors that may affect patient quality of life after removal of wisdom teeth. Ruta in 2000 (Ruta et al., 2000) proposed a postoperative symptom severity (PoSSe) scale created from questions commonly used in the clinical assessment of patients who have had third molars extracted, and divided into subscales corresponding to seven main adverse effects (Figure 22). Mean PoSSe scores are significantly related to: the number of impacted teeth; whether and how much bone was removed during the operation; the presence or absence of bruising and swelling; whether the patient was operated on under local or general anesthesia; and whether antibiotics were given. In the evaluation of the short term outcomes of the operation as part of a clinical trial of different treatments, therefore the full PoSSe scale is the more appropriate measure (Ruta et al., 2000).

The Final PoSSe Scale

1. EATING

a. In the **last week**, has your operation affected your **enjoyment** of food?
*(Please mark **one** box)*
No, not at all [0] Yes, a little [5.25] Yes, very much [10.5]

b. In the **last week**, for how many days were you unable to **open your mouth** normally because of your operation?
*(Please mark **one** box)*
0 days [0] 1–2 days [2.63] 3–4 days [5.25] 5–6 days [7.88] 7 days [10.5]

2. SPEECH

a. In the **last week**, for how many days was your **voice** affected because of your operation?
*(Please mark **one** box)*
0 days [0] 1–2 days [1.25] 3–4 days [2.5] 5–6 days [3.75] 7 days [5]

b. On the **worst day** of the **last week**, how badly was your **speech** affected by your operation?
*(Please mark **one** box)*
Not at all [0] Slightly [1.25] Moderately [2.5] Severely [3.75] Unable to speak at all [5]

3. SENSATION

a. Thinking of the **last week**, for how many days were your lips or tongue feeling **tingling** because of your operation?
*(Please mark **one** box)*
None at all [0] 1–2 days [2] 3–4 days [4] 5–6 days [6] 7 days [8]

b. Thinking of the **last week**, for how many days were your lips or tongue feeling **numb** because of your operation?
*(Please mark **one** box)*
None at all [0] 1–2 days [2] 3–4 days [4] 5–6 days [6] 7 days [8]

4. APPEARANCE

a. Thinking of the **last week**, for how many days were your face and/or neck **bruised** because of your operation?
*(Please mark **one** box)*
None at all [0] 1–2 days [1.5] 3–4 days [3] 5–6 days [4.5] 7 days [6]

b. Thinking of the **last week**, for how many days were your face and/or neck **swollen** because of your operation?
*(Please mark **one** box)*
None at all [0] 1–2 days [1.5] 3–4 days [3] 5–6 days [4.5] 7 days [6]

5. PAIN

a. Thinking of the **last week**, for how many days did you experience **pain** from your operation?
*(Please mark **one** box)*
None at all [0] 1–2 days [2.38] 3–4 days [4.75] 5–6 days [7.13] 7 days [9.5]

b. Thinking of the **last week**, has the pain from your operation been controlled by **painkillers**?
*(Please mark **one** box)*

I have had no pain. [0]
Yes, completely controlled. [2.38]
Controlled mostly but still some discomfort. [4.75]
Poorly controlled. [7.13]
Not controlled at all. [9.5]

6. SICKNESS

a. Thinking of the **last week**, for how many days did you **vomit** or **feel nauseated**?
*(Please mark **one** box)*
None at all [0] 1–2 days [1.25] 3–4 days [2.5] 5–6 days [3.75] 7 days [5]

b. On the **worse day** of the last week, **how many times** did you vomit or feel nauseated?
(Please mark ***one*** box)

Not at all [0]	One day [1.25]	2–3 times [2.5]	More than 3 times [3.75]	All the time (all day long) [5]

7. INTERFERENCE WITH DAILY ACTIVITIES

a. In the **last week**, did the operation prevent you from carrying out **work/housework** and other **daily activities**?
(Please mark ***one*** box)

No, not at all. [0]
I could continue with my work, but my work suffered. [0.83]
Yes, for 1 day. [1.65]
Yes, for 2–6 days. [2.48]
Yes, for 7 days. [3.3]

b. In the **last week**, have your **leisure activities** been affected by your operation? (including sports, hobbies and social life)
(Please mark ***one*** box)

Not affected by the operation. [0]
Mildly affected by the operation. [0.83]
Moderately affected by the operation. [1.65]
Severely affected by the operation. [2.48]
The operation prevented any social life at all. [3.3]

c. Thinking of the **last week**, how badly did the pain affected your **life**?
(Please mark ***one*** box)

Not at all [0]	Slightly [1.1]	Moderately [2.2]	Severely [3.3]

FIGURE 22 POSSE SCALE

THE INFLUENCE OF MAGNIFYING SYSTEMS ON THE THIRD LOWER MOLAR EXTRACTION: OPERATOR POSTURAL ASSESSMENT

MATERIALS AND METHODS

The purpose of our study is to evaluate operator posture using the Rapid Upper Limb Assessment (RULA) method developed by McAtamney and Corlett of the University of Nottingham in 1993 (Institute for Occupational Ergonomics). RULA method is an international method that allows a quantitative analysis of the major risk factors for workers. In particular, the stresses of the upper anatomical district are considered by RULA method.

The study is a randomized controlled three arms clinical trial. It is in collaboration with Politecnico of Milan, Electronic Engineer Department, prof. Marco Marcon.

Between March 2017 and May 2018, at the Ospedale Santi Paolo e Carlo, Unità Operativa Complessa Odontostomatologia II in Milan (Italy) directed by Prof. Carrassi, 90 extractions of lower third on 65 patients were carried out. All those patients who needed to extract both lower molars were treated in two separate sessions, and the second intervention was performed only after complete healing.

Inclusion and exclusion criteria are summarized in the table below:

Inclusion	**Exclusion**
3.8 or 4.8 dysodontiasis	pregnancy
Need to perform a mucoperiosteal flap	Breastfeeding
Need to perform osteotomy and/or odontotomy	General contra indication to surgery

TABLE 7 INCLUSION AND EXCLUSION CRITERIA

The study has been approved by the Ethics Committee of the University of Milan and patients were asked to sign a specific informed consent to take part in the research protocol. The patients were enrolled at the Ospedale Santi Paolo e Carlo, Unità Operativa Complessa Odontostomatologia II in Milan (Italy). The dental clinic in which the study was conducted is a public structure affiliated to the National Health System where people that meet the essential healthcare levels are eligible for free medical care.

In the first appointment, the need for extraction of the third lower molar was verified.
All patients were treated in an outpatient setting. During the first visit, the clinician will collect the patient's remote and next medical history and will carry out an accurate, objective examination of the oral mucous membranes and dental arches. The clinician will also assess if the patient meets the inclusion criteria of the study. Following that, the participation in the clinical trial will be proposed to the patient, after clarification on the various aspects and methods of conducting. If the patient agrees to participate, the informed consent of the clinical study and the intervention will be given to him, which must be returned signed no later than the next visit.
Once the patient has accepted to participate in the study and has signed the informed consent, the appointment for surgical procedure is planned.
The type of intervention was explained to the patient and was asked to consent for the acquisition of clinical pictures and videos too. Surgical technique is the same used for extraction of the lower third molar. Patients enrolled in the study will not be exposed to any additional risk than the usual surgery techniques.

Professor Giovanni Lodi, head of research, performed randomization in three groups with stratifications 38 and 48:

A (Operating Microscope),

B (Surgical Loupes with coaxial illumination)

C (Naked Eye).

The intervention will be performed under local anesthesia (mepivacaine 20 mg/ml with adrenaline 1:100000) and by the use of microscope (OPMI Movena S7) or surgical loupes or no magnifying system.

During this session, the following data will be collected for the study:

1. Demographic data (baseline)
2. Medical and dental history
3. Parameters related to the lower third molar
4. Radiographic tests
5. Marker operator position
6. Pre- and postoperative photographs

The procedure was performed by a single operator, an expert oral surgeon assisted by a dental student.

The operator is an expert user of magnifying systems in oral surgery.

We considered the interventions performed on the left side and the right side in the same way. The operator has always been positioned on the same side of the extracted tooth.

In order to track the upper body, it was decided to cover all the body landmarks from head to sacrum. In particular, we decided to place two markers on the back of the surgical cap to track the position of the head. One marker was placed at the bottom of the neck, two between the shoulder blades following along the spinal column and three in the lumbar region also along the spinal column. Two markers were placed on the back in correspondence of the clavicles and two more in correspondence of the shoulders. Finally, two lines of three markers each were set on the back, parallel to the spinal column marker line, on both sides. We applied a set of markers on the back of a tight T-shirt worn by the dentist during the whole operation that was acquired using a 5 MPixels Gigabit ethernet camera.

Figure 23 5 MPixels Gigabit ethernet camera Genie Nano Series™

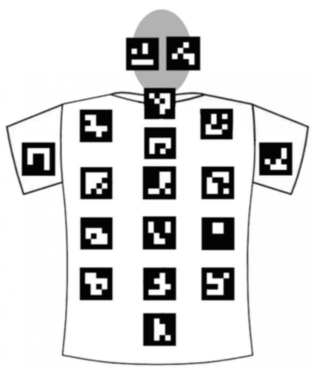


Figure 24 adopted markers arrangements.

FIGURE 25 CAMERAS DISPOSITION FOR A RIGHT SIDE TOOTH REMOVAL OPERATION

The surgeon performed the interventions from the same side of the tooth, right side for 4.8 and left side for the 3.8 wisdom teeth. We wanted to create a setup that accurately reproduces real work conditions to make data collection on posture as true as possible. All the instruments for data acquisition were positioned from the same side of the operator. On the same day WE collected the interventions of one side.

In the operating room, present there was the surgeon, two students, two engineers and the patient.

The day of intervention, the surgeon didn't know in which way he would have to extract the tooth. A few minutes before the intervention, a student opened the opaque envelope of randomization. In the same day, we collected the intervention of one side, and we did a maximum of four interventions per day.

After performing the local anesthesia, it takes a few minutes to check the cameras and set up the ideal starting posture. When everything was ready, a countdown started, and the recording began.

The first surgical step recorded was the incision, we decided not to include the anesthesia in this study

We tracked the postural evolution of the dentist's backbone, neck and head during the whole operation.

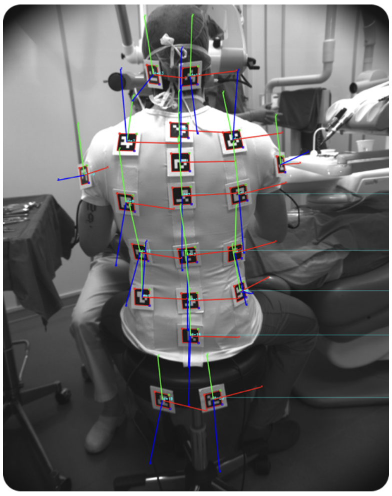


FIGURE 26 STARTING POSITION AND MARKER RECOGNIZED IN A 4.8 OPERATING MICROSCOPE INTERVENTION

Data analysis

For each group (naked eye, surgical loupes and microscope), we collected data of neck and trunk forward bending, side bending and twist (see chapter Postural Assessment in Dentistry).

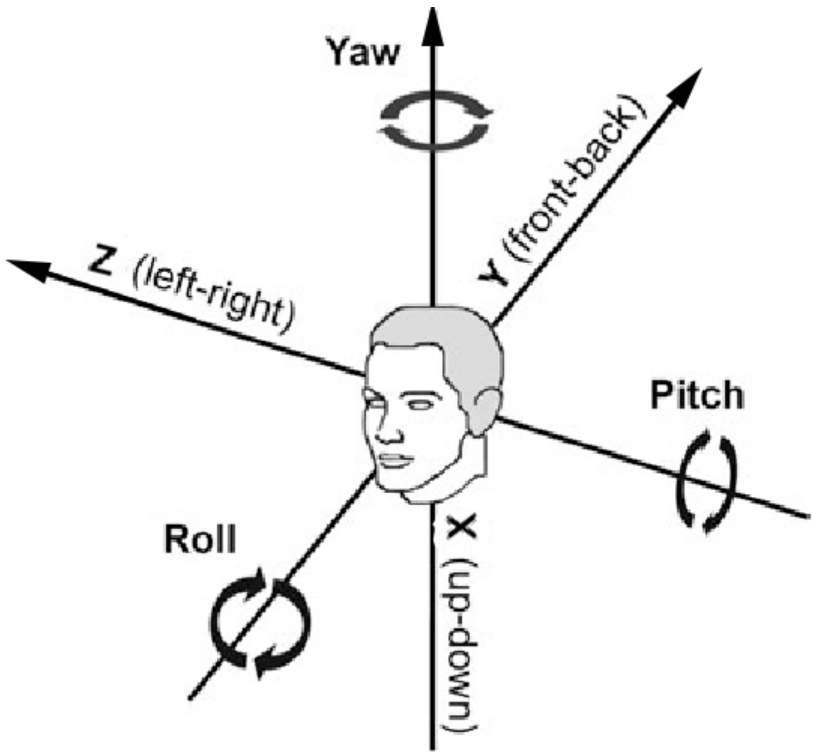


FIGURE 27 AXIS ORIENTATION

It was considered the average angle during the whole operation for every data. Left and right side interventions were evaluated in the same way. We didn't consider a difference between left side bending or right side bending as indicated in the RULA method. In order to the compare data, we eliminated the minus sign in the left side bending. We did the same for neck and trunk twist.

The final average value of neck and trunk of each group of intervention was considered for final analysis.

The data was compared using the ANOVA (Analysis of Variance). A post-hoc test was performed to highlight the differences between groups.

RULA worksheet (Figure 5) was used to analyze data and get the WMSDs risk score. In the worksheet, there are a lot of values to be considered to assess the final WMSDs risk. If we look at the dentist posture during the extraction of third lower molar, no matter what the magnifying system was used, the only variables are neck and trunk inclinations. We assigned the same score to all intervention in the non-variable boxes in table A and B. After calculating the correct values in empty boxes in table B, we get the final score in Table C.

RESULTS

Neck Forward Bending

In the table below, we reported neck bending data. In the boxes the mean values are shown of neck inclination in relation to the back during the whole operation. The average final score for the naked eye group is 26.03 degrees, for the Surgical Loupe 15.67 and for the Operating Microscope 3.63.

NECK Forward BENDING	Naked Eye	Surgical Loupe	Operating Microscope
1	27	18	5
2	25	18	5
3	27	14	2
4	22	24	3
5	27	20	5
6	30	16	0
7	31	22	4
8	26	13	3
9	26	17	9
10	24	11	4
11	31	19	3
12	30	17	5
13	24	15	3
14	24	14	2
15	29	16	4
16	25	11	2
17	28	16	4
18	22	12	2
19	25	11	3
20	23	17	5
21	23	14	7
22	31	23	2
23	25	11	1
24	21	7	3
25	24	19	9
26	27	20	4
27	25	11	1
28	22	20	2
29	30	13	3
30	27	11	4
	Average	Average	Average
	26.03	15.67	3.63

TABLE 8 NECK FORWARD BENDING

Analysis of variance (ANOVA) was used to compare between variables of normal distribution. Neck bending was significantly different between the groups (p-value). Use of magnification instrument improve neck posture. The post-hoc test outlined the difference between the three groups, and the microscope got the best results. There was also a significant difference between surgical loupes and naked eye.

	n	Bending (degrees)	SD	*p-value*
naked eye	30	26.03	2.95	*<0.05*
surgical loupes	30	15.67	4.15	
operating microscope	30	3.63	2.07	

TABLE 9 P-VALUE NECK FORWARD BENDING

Post hoc test	*p-value*
naked eye VS surgical loupes	*<0.05*
naked eye VS operating microscope	*<0.05*
surgical loupes VS operating microscope	*<0.05*

TABLE 10 POST-HOC TEST NECK FORWARD BENDING

Neck Side Bending

Data of neck side bending showed a significant difference between the three groups. Average values range from 5.3 to 1.13. The p ost-hoc test highlighted the best results obtained by the microscope. No differences emerged between the naked eye and surgical loupe.

NECK Side BENDING	Naked Eye	Surgical Loupe	Operating Microscope
1	6	6	1
2	4	4	0
3	4	3	0
4	4	7	2
5	6	6	1
6	6	6	0
7	5	7	1
8	3	3	2
9	4	7	5
10	3	6	0
11	6	8	0
12	4	6	1
13	3	5	1
14	4	5	2
15	6	3	1
16	5	3	0
17	7	7	2
18	3	7	2
19	7	5	2
20	5	7	1
21	7	5	0
22	4	8	2
23	5	7	2
24	3	3	1
25	5	5	0
26	9	6	0
27	8	7	0
28	5	9	1
29	11	6	3
30	7	5	1
	Average	Average	Average
	5.3	5.73	1.13

TABLE 11 NECK SIDE BENDING

	n	Bending (degree)	SD	*p-value*
naked eye	30	5.3	1.91	*<0.05*
surgical loupes	30	5.73	1.64	
operating microscope	30	1.13	1.14	

TABLE 12 P-VALUE NECK SIDE BENDING

Post hoc test	*p-value*
naked eye VS surgical loupes	*0.35*
naked eye VS operating microscope	*<0.05*
surgical loupes VS operating microscope	*<0.05*

TABLE 13 POST-HOC NECK SIDE BENDING

Neck Twist

There was a big difference among the three groups in terms of the neck twist. In particular, between the microscope and the other two magnification groups. The naked eye got the worst result with 18.57 degrees, the surgical loupe 17.20 degree and operating microscope 3.17 degrees.

NECK Twist	Naked Eye	Surgical Loupe	Oper ting Microscope
1	18	17	5
2	15	17	4
3	17	12	1
4	12	18	1
5	11	19	3
6	15	19	6
7	11	13	4
8	16	15	2
9	18	11	6
10	18	18	2
11	21	18	2
12	17	18	1
13	12	12	3
14	12	11	4
15	19	14	5
16	21	19	4
17	25	25	6
18	23	17	5
19	20	15	2
20	17	19	2
21	19	16	6
22	23	25	0
23	22	21	3
24	20	14	2
25	20	21	5
26	25	19	3
27	23	20	3
28	19	20	0
29	25	17	2
30	23	16	3
	Average	Average	Average
	18.57	17.2	3.17

TABLE 14 NECK TWIST

	n	Bending (degree)	SD	*p-value*
naked eye	30	18.57	4.22	*<0.05*
surgical loupes	30	17.2	3.56	
operating microscope	30	3.17	1.78	

TABLE 15 P-VALUE NECK TWIST

Post hoc test	*p-value*
naked eye VS surgical loupes	*0.18*
naked eye VS operating microscope	*<0.05*
surgical loupes VS operating microscope	*<0.05*

TABLE 16 POST-HOC TEST NECK TWIST

Trunk Forward Bending

Forward bending of the trunk ranges from 8 to 7 degrees. There were no differences between the three groups. Table 17 shows reported data of interventions and in Table 18 the statistical analysis that confirms no significative difference.

Trunk FOR WARD BENDING	Naked Eye	Surgical Loupe	Operating Microscope
1	8	6	6
2	8	8	7
3	10	6	7
4	6	6	7
5	10	4	6
6	7	5	6
7	6	5	7
8	8	3	4
9	4	5	6
10	8	9	5
11	7	8	6
12	7	9	5
13	6	6	5
14	6	7	6
15	8	8	7
16	8	7	10
17	9	6	11
18	12	8	8
19	8	6	6
20	10	6	6
21	5	9	7
22	7	12	6
23	7	12	10
24	7	7	5
25	7	6	8
26	9	12	6
27	10	8	4
28	8	7	5
29	10	11	7
30	7	8	9
	Average	Average	Average
	7.83	7.25	6.65

TABLE 17 FORWARD BENDING

	n	Side Bending (degree)	SD	*p-value*
naked eye	30	7.83	1.77	0.0636
surgical loupes	30	7.25	2.25	
operating microscope	30	6.65	1.68	

TABLE 18 P-VALUE TRUNK TWIST

Trunk Side Bending

We analyzed trunk side bending, data concerning all interventions are listed in the table below.

Trunk SIDE BENDING	Naked Eye	Surgical Loupe	Operating Microscope
1	11	8	10
2	7	11	6
3	9	13	8
4	8	4	6
5	9	10	5
6	8	10	5
7	8	9	4
8	5	9	4
9	9	12	8
10	7	12	5
11	9	8	6
12	6	8	7
13	9	10	6
14	8	8	9
15	7	11	6
16	6	15	5
17	16	10	5
18	13	7	7
19	12	5	7
20	9	3	6
21	7	8	3
22	6	14	6
23	6	8	5
24	6	7	5
25	5	5	5
26	7	13	4
27	10	5	7
28	7	11	4
29	8	9	6
30	5	4	6
	Average	Average	Average
	8.12	8.92	6.01

TABLE 19 TRUNK SIDE BENDING

The values in the Operating Microscope group were significantly lower compared to the other two groups. No statistically significant differences were observed between the naked eye and the surgical loupes.

	n	Side Bending (degree)	SD	*p-value*
na ked eye	30	8.12	2.45	*<0.05*
surgical loupes	30	8.92	3.03	
operating microscope	30	6.01	1.50	

TABLE 20 P-VALUE TRUNK BENDING

Post hoc test	*p-value*
naked eye VS surgical loupes	*0.2713*
naked eye VS operating microscope	*<0.05*
surgical loupes VS operating microscope	*<0.05*

TABLE 21 POST-HOC TEST TRUNK BENDING

Trunk Twist

The data recorded for trunk twist showed very similar results. Nevertheless, statistical analysis revealed a significant difference between the three groups. Operating Microscope showed the best results compared to naked eye and surgical loupes groups.

TRUNK TWIST	Naked Eye	Surgical Loupe	Operating Microscope
1	9	5	8
2	4	8	5
3	6	8	6
4	5	2	4
5	7	6	3
6	3	3	3
7	5	4	3
8	3	5	8
9	6	6	7
10	7	10	5
11	8	8	7
12	5	4	4
13	6	6	3
14	6	6	4
15	5	5	5
16	3	7	5
17	7	7	2
18	8	6	5
19	4	4	4
20	4	2	4
21	5	4	3
22	9	10	5
23	4	4	5
24	6	6	3
25	4	4	5
26	5	7	2
27	7	3	5
28	6	6	5
29	4	5	4
30	4	6	4
	Average	Average	Average
	5.60	5.58	4.52

TABLE 22 TRUNK TWIST

	n	twist (degree)	SD	*p-value*
naked eye	30	5.60	1.75	0.0454
surgical loupes	30	5.58	2.01	
operating microscope	30	4.52	1.56	

TABLE 23 P-VALUE TRUNK TWIST

Post hoc test	*p-value*
naked eye VS surgical loupes	0.8906
naked eye VS operating microscope	*<0.05*
surgical loupes VS operating microscope	*<0.05*

TABLE 24 POST-HOC TEST TRUNK TWIST

FINAL VALUES

In the table below, we summarized the final average values of all interventions in the three groups.

	Neck			Trunk		
	Forward bending	Side bending	Twist	Forward bending	Side bending	Twist
Operating Microscope	3.63	1.13	3.17	6.65	6.01	4.52
Surgical Loupes	15.67	5.73	17.20	7.25	8.92	5.58
Naked Eye	26.03	5.30	18.57	7.83	8.12	5.60

TABLE 25 FINAL VALUES OF NECK AND TRUNK

RULA

The RULA approach uses three scoring tables to provide evaluation of exposure risk to WMSDs. The assessment is based on the analysis of the arm, wrist, neck, trunk and leg position.

All the extractions of the third lower molars were performed by the same surgeon in the same dental setting. In this way we have the same postural conditions to compare the three groups of magnification accurately. Considering the RULA worksheet and observing surgeon posture, Table A has the same score in all interventions (Figure 28). The upper arms were located parallel to the trunk in lateral view as shown in the first picture of RULA worksheet. In the front view, the upper arms were abducted from the trunk. The shoulders were not raised. In our setting the arms are not supported. We could assign score 1 to the blue box of the final upper arm score.

The lower arms were placed between 60 and 100 degrees from the upper arms, and one arm worked repetitively across the midline. The final lower arm score, 2, is in the pink box.

The wrist is bent and twisted near the end of the range, and we assigned 3, respectively, in the yellow box and 2 in the green striped box. We can now match all results obtained and calculate the final score, in table A, it is 4 for all interventions. To get the final score in the purple box, we had to consider the muscle and load score (steps 6 and 7). The posture during chairside work is mainly static, and the action repeated occurs more than four times per minute (score 1 in first white box), but none of the instruments weigh more than 4.4lbs (score 0 in second white box). Steps 10, 11,13 and 14 were, also in this case, the same in all groups. The data collected from the markers showed a forward bending of the trunk between 3 and 12 degrees. The twist was from 2 to 10 and side bending from 3 to 13. Despite the wide variability of the data, we had to assign a score of 4 (blue striped box) for all interventions because the first range considered in RULA is 0 degrees, and the second is from 0 to 20 degrees.

Legs and feet are supported, so we assigned a score of 1 in the light yellow box.

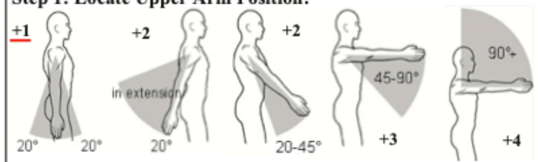
The steps 13 and 14 are similar to steps 6 and 7, also in this case, score 1 was assigned.

The final results for the purple striped box of Table B depends on step 9. The n eck score in the green box is the only variable that changes in all interventions.

If we considered the intervention with the worst result, 31 degrees (Figure 31), the final score in the purple striped box is 9. This means that the score in table C is 7 which indicates a high risk of WMSDs. On the other hand, if we consider the intervention with the best result, 0 degrees (Figure 32), the related score in the purple striped box is 6 and the final score in table C is 4, which is a high risk of WMSDs. All interventions were at high risk of WMSDs independently from magnification device used.

A. Arm and Wrist Analysis

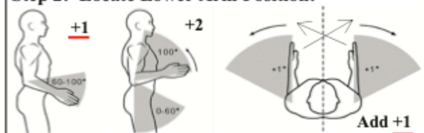
Step 1: Locate Upper Arm Position:



Step 1a: Adjust…
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

2
Upper Arm Score

Step 2: Locate Lower Arm Position:

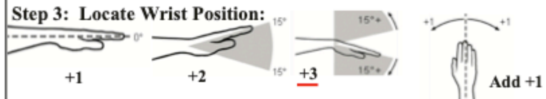


Add +1

2
Lower Arm Score

Step 2a: Adjust…
If either arm is working across midline or out to side of body: Add +1

Step 3: Locate Wrist Position:



Step 3a: Adjust…
If wrist is bent from midline: Add +1

4
Wrist Score

Step 4: Wrist Twist:
If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

2
Wrist Twist Score

Step 5: Look-up Posture Score in Table A:
Using values from steps 1-4 above, locate score in Table A

4
Posture Score A
+

Step 6: Add Muscle Use Score
If posture mainly static (i.e. held>1 min)
Or if action repeated occurs 4X per minute: +1

1
Muscle Use Score
+

Step 7: Add Force/Load Score
If load < 4.4 lbs (intermittent): +0
If load 4.4 to 22 lbs (intermittent): +1
If load 4.4 to 22 lbs (static or repeated): +2
If more than 22 lbs or repeated or shocks: +3

0
Force/Load Score
=

Step 8: Find Row in Table C
Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in **Table C**.

5
Wrist & Arm Score

SCORES

Table A: Wrist Posture Score

Upper Arm	Lower Arm	Wrist 1, Wrist Twist 1	Wrist 1, Wrist Twist 2	Wrist 2, Wrist Twist 1	Wrist 2, Wrist Twist 2	Wrist 3, Wrist Twist 1	Wrist 3, Wrist Twist 2	Wrist 4, Wrist Twist 1	Wrist 4, Wrist Twist 2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table C: Neck, trunk and leg score

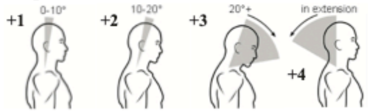
Wrist and Arm Score	1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Scoring: (final score from Table C)
1 or 2 = acceptable posture
3 or 4 = further investigation, change may be needed
5 or 6 = further investigation, change soon
7 = investigate and implement change

Final Score

B. Neck, Trunk and Leg Analysis

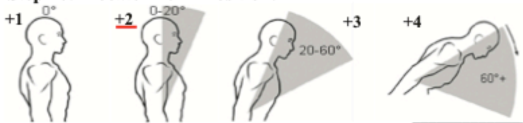
Step 9: Locate Neck Position:



X+1+1
Neck Score

Step 9a: Adjust…
If neck is twisted: +1
If neck is side bending: +1

Step 10: Locate Trunk Position:



2+1+1
Trunk Score

Step 10a: Adjust…
If trunk is twisted: +1
If trunk is side bending: +1

Step 11: Legs:
If legs and feet are supported: +1
If not: +2

1
Leg Score

Table B: Trunk Posture Score

Neck Posture Score	1, Legs 1	1, Legs 2	2, Legs 1	2, Legs 2	3, Legs 1	3, Legs 2	4, Legs 1	4, Legs 2	5, Legs 1	5, Legs 2	6, Legs 1	6, Legs 2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Step 12: Look-up Posture Score in Table B:
Using values from steps 9-11 above, locate score in Table B

X
Posture Score B
+

Step 13: Add Muscle Use Score
If posture mainly static (i.e. held>1 min)
Or if action repeated occurs 4X per minute: +1

1
Muscle Use Score
+

Step 14: Add Force/Load Score
If load < 4.4 lbs (intermittent): +0
If load 4.4 to 22 lbs (intermittent): +1
If load 4.4 to 22 lbs (static or repeated): +2
If more than 22 lbs or repeated or shocks: +3

0
Force/Load Score
=

Step 15: Find Column in Table C
Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in **Table C**.

X
Neck, Trunk & Leg Score

FIGURE 28 RULA WORKSHEET

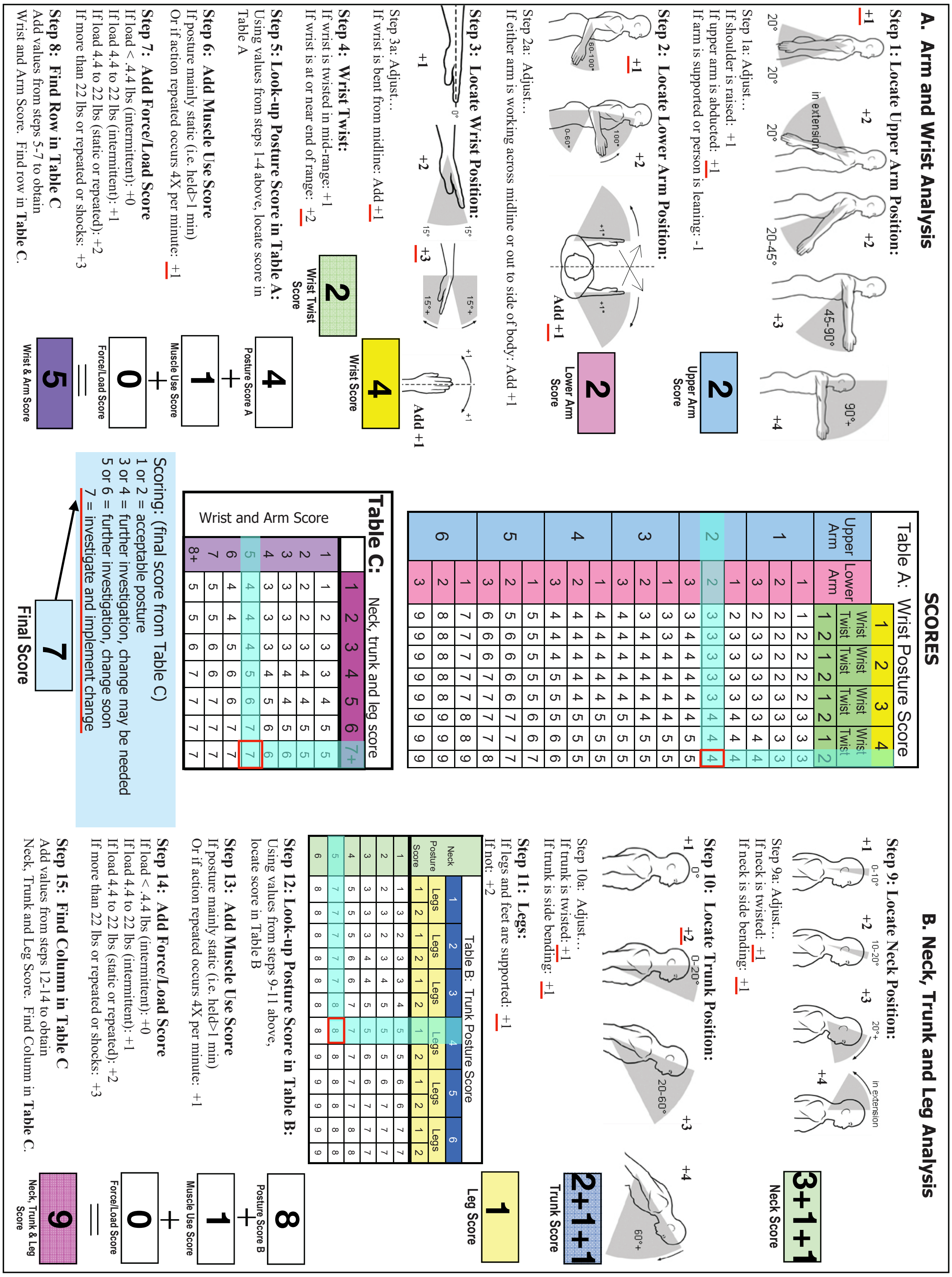


FIGURE 29 RULA WORKSHEET, NECK BENDING 31 DEGREES

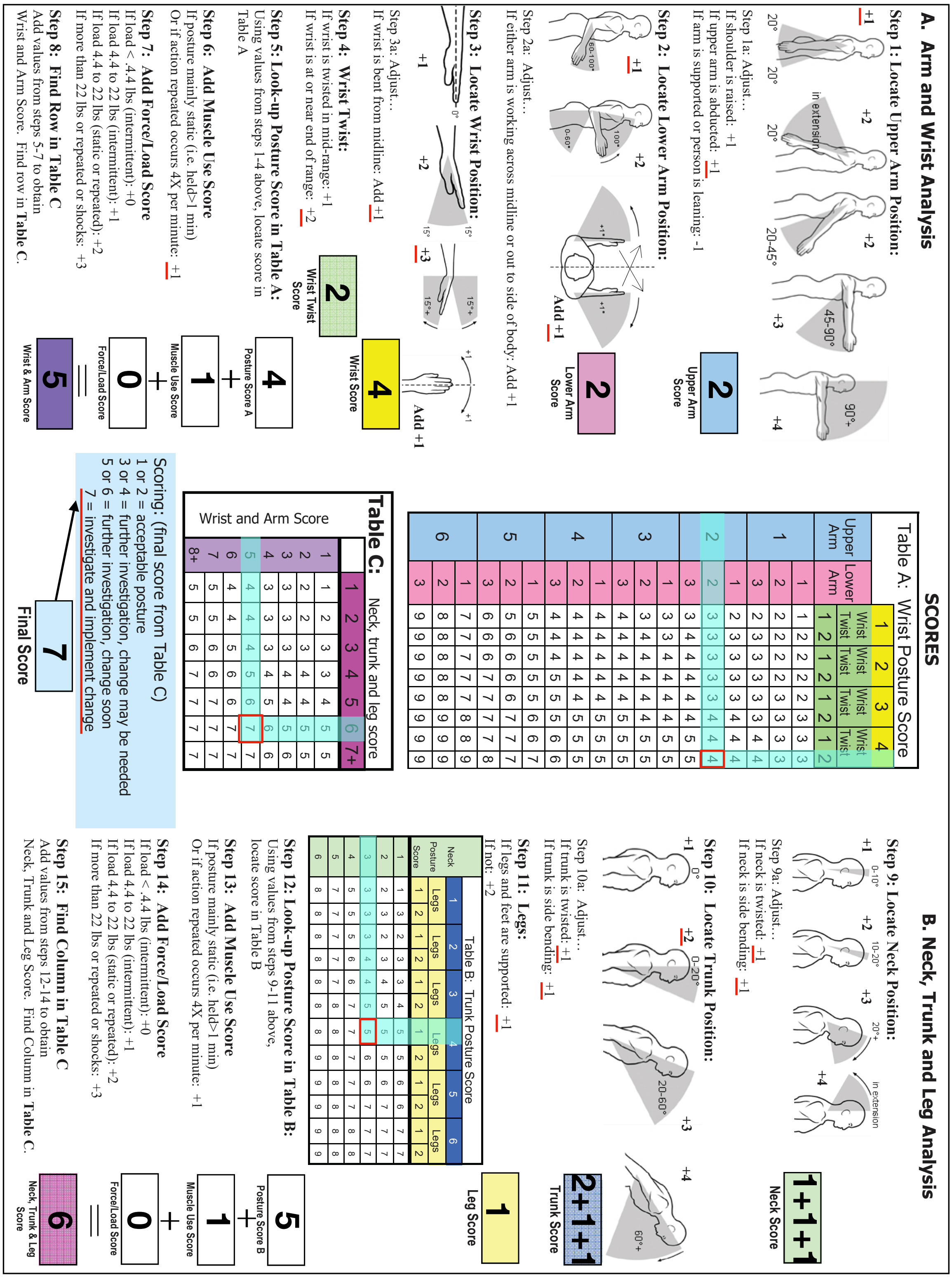


FIGURE 30 RULA WORKSHEET, NECK BENDING 0 DEGREES

DISCUSSION

The goal of our study was to investigate if the use of magnification in dentistry could improve posture for dental practitioners and reduce the risk of onset of WMSDs. To accurately assess dentist posture, we decided to perform the same intervention in all patients, in the same settings with the same operator. We propose an advanced approach to evaluate the dentist posture accurately and objectively. A set of markers were applied on the back of a customized tight T-shirt worn by the dentist during the whole operation that was acquired using a 5 MPixels Gigabit ethernet camera (Marcon, Pispero, Pignatelli, Lodi, & Tubaro, 2018). Our method uses fiducial markers with a non-invasive approach, and we were able to follow the 3D position and orientation of all the limbs involved in a specific activity during the job execution. Tracking the markers with two cameras, we exactly knew the posture of the operator and the time he kept an awkward position. We eliminated the variables related to the observer, and we discriminated one degree of bending or twisting only from a back view of the operator without interfering with the working activity.

We wanted to assess the feasibility of our experimental protocol, and for this reason we chose to test it on the same expert operator in 90 interventions. In further studies, we will aim to use this verified protocol on a large number of dentists at different levels of expertise.

The analysis of the data obtained was conducted using the RULA method (McAtamney & Corlett, 1993), a validated observation method used to estimate exposure to WMSDs. RULA method uses diagrams of upper body posture and three scoring table to provide an evaluation of the exposure to risk factors. Using the RULA worksheet, the evaluator will assign a score for each of the following body regions: upper arm, lower arm, wrist, neck, trunk, and legs. When using RULA, only the right or left side is assessed at a time. The results obtained are based on direct observation from one evaluator. In this way, we can get only approximate results with a large variability that depends on the skill of the observer.

The RULA ergonomic assessment tool considers biomechanical and postural load requirements of job tasks/demands on the neck, trunk and upper extremities. A single-page worksheet is used to evaluate required body posture, force, and repetition. Based on the evaluations, scores are entered for each body region in section A for the arm and wrist, and section B for the neck and trunk (McAtamney & Corlett, 1993). If we consider a dentist in a sitting posture, we can see that in all interventions, upper and lower limbs, are in the same position. We reproduced a standard-setting without a customized ergonomic stool and dental chair. The operator's arms were not supported, and the backrest of the dental chair was not extra thin.

From step 1 to step 8 in the RULA worksheet, we put the same score in all cases, in the same way we do in steps 11, 13 and 14. By the use of magnification system, the operator's posture didn't change in terms of leg positioning or arm raising and wrist twist. We tried to get the best posture, in any condition, and that was possible thanks to the expertise of the surgeon (with and without magnification). The distance work was the only variable we found. It was involved neck and trunk forward bending, and in a small part also neck and trunk twist and side bending.

If we first consider data of trunk movements, we could see that there was no substantial difference between the three groups. No statistically significant differences emerged from data of forward bending. That results could be explained by the trend of the operator to keep a correct position of the trunk and to compensate for the variability of work distance by the place of the patient in the best way and reducing bending. In side bending and twist, we observed statistically significant data, and the best results were obtained from using the

Operating Microscope. In RULA worksheet, there are no range of values for twist and side bending, and this could be explained because it's difficult to estimate the entity of this movement for the observer. Moreover, side bending and twist are awkward positions that have to be avoided as much as possible. For this reason, we gave the same score to step 10 in all interventions.

In RULA worksheet, the only score that changes is the neck bending in step 9. The final score depends on this score. We verified that despite the big range between neck bending, from 31 to 0 degrees, the final RULA score is the same for all interventions. Neck bending was not able to affect the final score because dentist work is a caring profession that is exposed to WMSDs in a vast number of dentists, as shown in many reviews (Hayes et al., 2009). The onset of WMSDs, from a posture point of view, depends on many movements and positions of wrist, lower and upper arm, trunk and static posture. The importance of neck bending is low if others variables have had a bad score.

THE INFLUENCE OF MAGNIFYING SYSTEMS ON THIRD LOWER MOLAR EXTRACTION: CLINICAL ASSESSMENT

The use of the magnifying system in oral surgery is not so widespread. The need for a wide depth of field is one of the most frequent issues, in particular in implantology. However, the importance of non-invasive surgery in all branches of dentistry has attracted attention to the magnifying system. If on the one hand, surgical loupes are easy to use and are wearable and transportable devices; and on the other hand, the operating microscope is a high performing system. In our study, we decided to test the efficiency of the microscope comparing it to surgical loupes and the naked eye in the most frequent interventions in oral surgery, the extraction of the third lower molar.

MATERIALS AND METHODS

The study is a randomized controlled three arms clinical trial. It is part of the previously mentioned study and we refer to "Materials and Methods" on page 41 for the introduction of this section.

Pre-operative data collection

The intervention will be performed under local anesthesia (mepivacaine 20 mg/ml con adrenaline 1:100000) and by the use of the operating microscope (OPMI Movena S7) or surgical loupes or no magnifying system.

During this session, the following data will be collected for the study:

1. Demographic data (baseline)
2. Medical and dental history
3. Parameters related to the lower third molar
4. Radiographic tests
5. Marker operator position
6. Pre- and postoperative photographs

The procedure will be performed by a single operator, specializing in oral surgery assisted by a dental student. The operator is an expert user of magnifying systems in oral surgery.

The data regarding the lower third molar was obtained from radiographic images (OPT or CT cone beam), including the position of the tooth according to Winter classification, degree of inclusion according to Pell and Gregory classification and number of roots. All the pre and intraoperative variables collected are reported in the table below:

Independent Variables (Preoperative and Operative)
Age (yrs)
≤22
23-29
>29
Gender
M
F
Tobacco use
Yes
No
Oral contraceptive use
Yes
No
Antibiotic prophylaxis
Yes
No
Indication for removal
Infection
Periodontal disease
Prophylactic removal
Orthodontics reason
Caries
Atypical facial pain
Number of roots
Multiple
Singular
Incomplete
Spatial relationship
Distoangular
Horizontal
Vertical
Mesioangular
Depth
Level A (high)
Level B (medium)
Level C (deep)
Ramus relationship/space available
Class I (sufficient)
Class II (reduced)
Class III (none)
Surgeon
1
2
3
Assistant surgeon
Clinical dental student
Resident
Specialist training
Flap design
Envelope flap
Vestibular triangular flap
Vestibular trapezoidal flap
Bone removal
Yes
No
Extraction difficulty
Elevator/forceps alone
Bone removal/tooth sectioning
Bone removal + tooth/root sectioning
Extremely difficult

TABLE 27 INDEPENDENT VARIABLES

The first 31 patients took prophylactic therapy with amoxicillin and clavulanic acid 1 gr tablets from the day before the operation up to the next 5 days, 1 tablet every 12 hours.

According to the most recent recommendations on the use of prophylactic antibiotic therapy in healthy patient and on the constant increase of bacterial resistance and allergic reactions, it was decided to no longer perform an antibiotic prophylaxis (Lodi et al., 2013).

Intervention

Before the extraction, a rinse was carried out with chlorhexidine 0.2% for about 1 minute. Each patient underwent the same surgical procedure, in the same operating room and n the same conditions.

A few minutes before the intervention, the surgeon discovered how to carry out the extraction: microscope, surgical loupes or naked eyes.

Locoregional anaesthesia was performed with 2% mepivacaine with adrenaline 1: 100,000 (Optocain 20 mg, Molteni Dental), no other local drugs or anaesthetics were used. Access to the third molar was performed by a mucoperiosteal flap and a vestibular osteotomy with a fissure burr under continuous irrigation. If necessary, a crown and / or root sectioning was performed using the same fissure burr. After extraction, the alveolus was inspected, curetted for granulation tissue removal, and irrigated with sterile saline solution. A 4/0 monofilament nylon suture was used to close the wound without tension.

Immediately after the operation, Nimesulide 100 mg for oral suspension was administered. A sterile gauze moistened was used to compress the wound for 10 minutes and an ice pack was then applied to the patient's face for 20 minutes. Patients were advised to take only Nimesulide 100 mg as needed a painkiller , on a full stomach, at most twice a day for three days after the intervention. It was also recommended to continue the ice application 20 minutes every one hour for at least five times. In the area of intervention, it was forbidden to brush the teeth until the removal of suture points. The oral hygiene was maintained only by chlorhexidine 0.2% mouth rinses twice a day for 10 days.

FIGURE 31 PREOPERATIVE RADIOGRAPH

FIGURE 32 PRE-OPERATIVE IMAGE

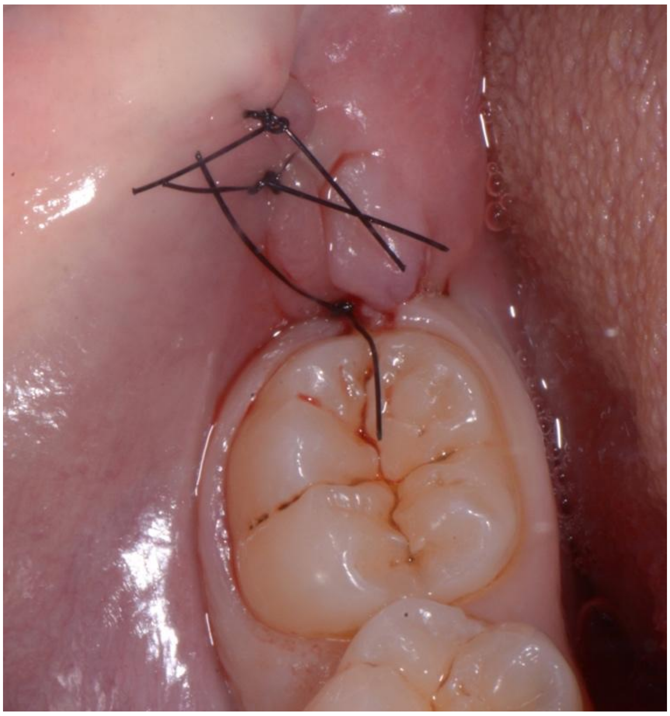


FIGURE 33 POST-OPERATIVE IMAGE

Post Operative Assessment

After 7 days the patient was called for the removal of stitches and the evaluation of the postoperative period. During this session, in addition to intraoral photographs, the following data was collected:

1. Number of painkillers taken
2. Visual Analog Scale (VAS)
3. Postoperative Symptom Severity scale (PoSSe)

The patient them self recorded the number of painkillers taken. The final number also included the painkillers administered by the operators in the immediate postoperative period.

The intensity of pain experienced during the week was recorded through the VAS, a one-dimensional visual scale, consisting of a 100 mm line with two extreme points representing "no pain" and "very severe pain" on which the patient marked with a point the average pain experienced during the week.

The Postoperative Symptom Severity scale was used to assess the perception of postoperative adverse effects. The PoSSe scale is divided into 7 subgroups: eating, speaking, sensitivity, appearance, pain, general conditions, carrying out daily activities. Every answer is assigned a score, and the sum of the scores of all the answers represents a percentage. In cases of patients who gave the worst answers to all questions were assigned the percentage of 100%, contrary to the patients who did not experience postoperative symptoms were assigned a percentage of 0%.

A patient from the "no antibiotics " group leaves the study because she didn’t come to the 7-day check-up.

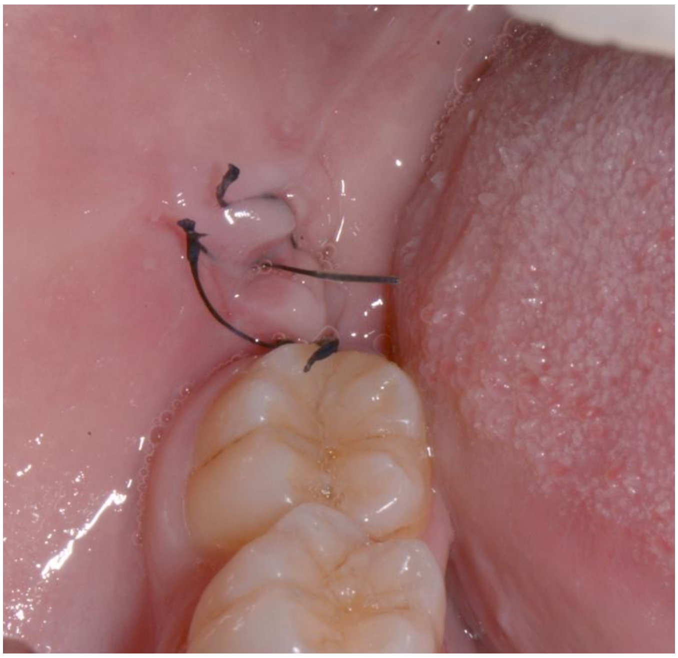


FIGURE 34 SEVEN DAYS CONTROL VISIT

RESULTS

Sample characteristics

65 patients, from March 2017 to May 2018, were enrolled in the study for a total of 90 extractions, with a Male: Female ratio of 1: 1.6. The demographic characteristics of the population are summarized in table below.

variables		n	%
age	≤22	37	41.11%
	23-29	35	38.89%
	>29	18	20.00%
gender	M	35	38.89%
	F	55	61.11%
smoking status	yes	15	16.67%
	no	75	83.33%

TABLE 28 DEMOGRAPHIC CHARACTERISTICS

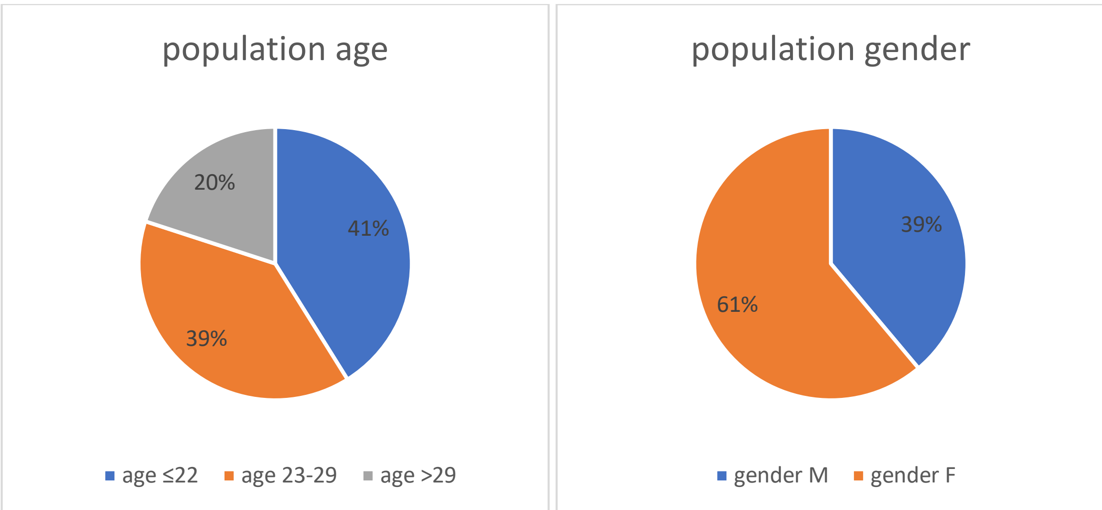


FIGURE 35 GRAPHIC REPRESENTATION OF POPULATION AGE AND GENDER

Antibiotic prophylaxis (amoxicillin and clavulanic acid 1 g, 1 tablet every 12 hours, from the day before the intervention for a total of 6 days) was administered to the first 31 patients (34.44%). Initially, we tried to perform a study to replicate what happens in most of the dental offices. The dentists generally prescribe antibiotics for the extraction of a third lower molar. After the first part of the study, we decided to retreat this policy according to recent reviews on this topic (Lodi et al., 2013). For this reason, in the following 59 (65.56%), no prophylactic antibiotic therapy was administered.

Sixty-four dental elements were extracted for periodontal disorders, 11 elements were extracted preventively due to the high risk of developing infectious diseases, 10 elements have had recurrent infections, 3 elements were extracted for orthodontic indications, 2 elements were extracted because they were decayed.

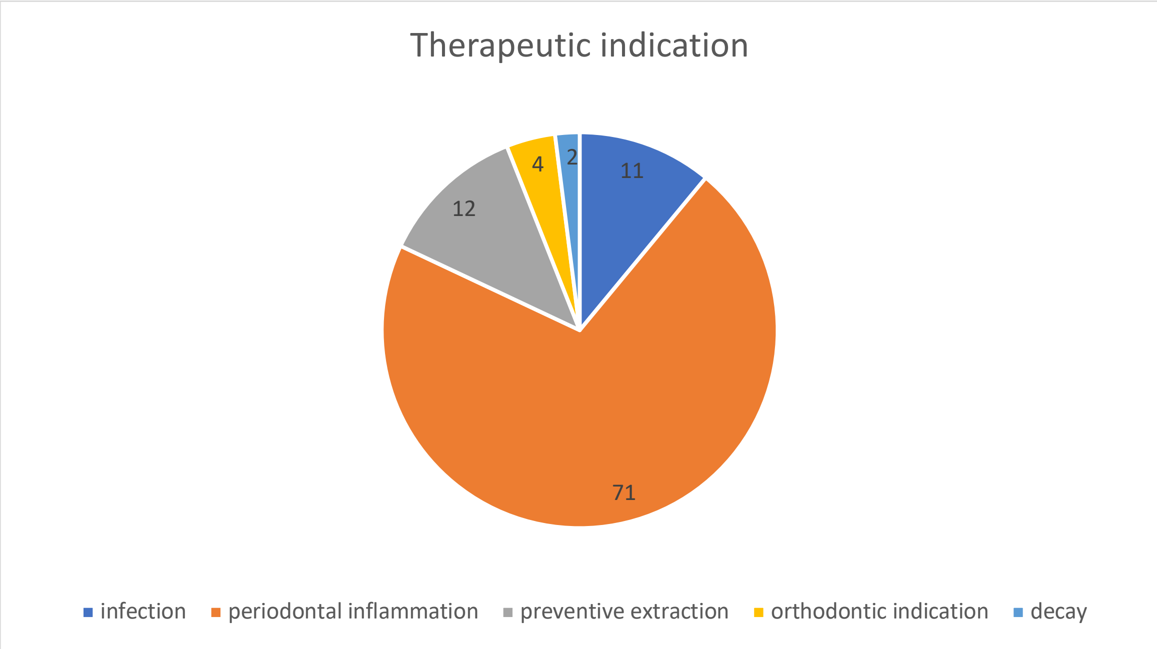


TABLE 29 THERAPEUTIC INDICATION

The characteristics referred to the anatomy and position of the third molar are summarized in Table 29 and include number of roots, spatial relationship (Winter's classification), depth of inclusion and the relationship with the mandibular branch (Pell and Gregory classification). The ratio between the multiple and singular roots element was 9:1 and almost half of the elements extracted were mesioangular (41.11%).

variables		n	%
Number of Roots	multiple	81	90.0
	singula	9	10.0%
	incomplete	0	0.0%
Spatial relationship	distoangular	10	11.1%
	horizontal	19	21.1%
	vertical	24	26.7%
	mesioangular	37	41.1%
Depth	A (high)	33	36.7%
	B (medium)	49	54.4%
	C (deep)	8	8.9%
Ramus relationship/ space available	Class I (sufficient)	62	68.9%
	Class II (reduced)	26	28.9%
	Class III (none)	2	2.2%

TABLE 30 CHARACTERISTICS OF THE TEETH

The interventions were performed by preparing an envelope flap, with one exception where the depth of inclusion of the third lower molar necessitated a trapezoidal flap.

In all of the interventions, osteotomy was performed, and only in 5 cases odontotomy was not necessary. According to a personal evaluation of the first operator, only 6 interventions (6.67%) turned out to be extremely difficult and correspond to those of longer duration. Table 6 shows variables related to the intervention.

variables		n	%
Flap design	Envelope	89	98.9%
	Vestibular triangular	0	0.0%
	Vestibular trapezoidal	1	1.1%
Bone removal	yes	90	100.0%
	no	0	0.0%
Extraction difficulty	Elevators /forceps alone	0	0.0%
	Bone removal/tooth sectioning	5	5.6%
	Bone removal + tooth/root sectioning	79	87.8%
	extremely difficult	6	6.7%
Operation time (min)	≤10	7	7.8%
	11-22	44	48.9%
	21-30	22	24.4%
	>30	17	18.9%

TABLE 31 OPERATIVE VARIABLES

The data was processed separately for the group of patients who took antibiotic prophylaxis and for the group who didn't take it. Many studies in the literature prove that antibiotics could influence the patient's postoperative complications and decrease the degree of pain (Lodi et al., 2013).

Antibiotic group

If we analyze the results obtained with VAS scale, the naked eye and surgical loupes do not differ substantially (31 mm). Similarly, the pain intensity in patients undergoing microscopic surgery is the same as when other magnifying systems are used (33 mm).

PoSSe scale, presents a slight difference between the three arms of treatment. The patients treated with surgical loupes experienced the worst post-operative symptoms (22.4%) contrary to the naked eye group of treatment where the best result was reported (16.5%). These results are not significant and the difference in values was due to chance. The data mentioned above disagrees with the number of painkillers taken in the naked eye group (8,2) which in this case, obtained the worst outcome especially if compared to microscope (5,7). However, no difference between the groups was found to be statistically significant.

	n	VAS	SD	*p-value*
Surgical loupes	11	30.7	19.7	*0.972*
Microscope	10	32.8	21.8	
Naked eye	10	31.3	23.9	

	n	PoSSe	SD	*p-value*
Surgical loupes	11	22.4	12.2	*0.477*
microscope	10	18.7	9.3	
Naked eye	10	16.5	11.0	

	n	No. painkillers	SD	*p-value*
Surgical loupes	11	6.3	6.4	*0.657*
microscope	10	5.7	4.8	
Naked eye	10	8.2	7.5	

TABLE 32 COMPARISON BETWEEN THREE TREATMENT ARMS IN ANTIBIOTIC GROUP

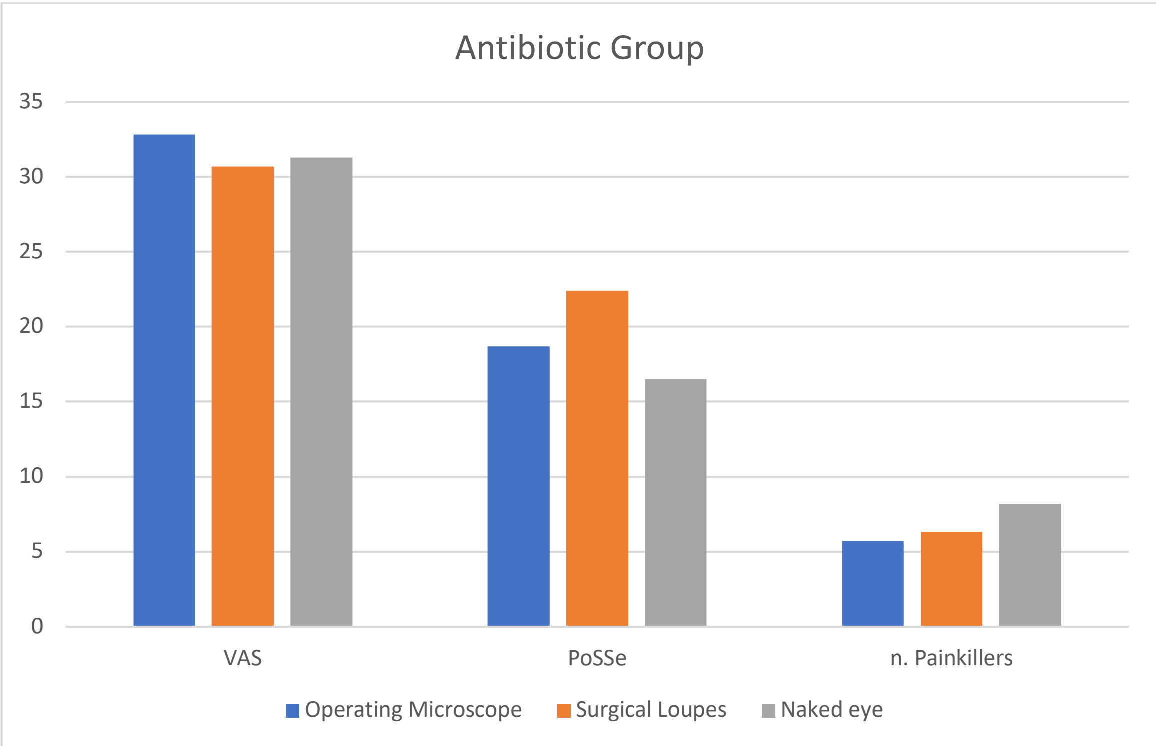


FIGURE 36 GRAPHIC REPRESENTATION OF COMPARISON BETWEEN THREE TREATMENT ARMS IN THE ANTIBIOTIC GROUP

No antibiotic group

In patients who have not taken antibiotic prophylaxis, the method that obtains the best values for pain intensity and quality of life is the naked eye, with a VAS of 23.20 mm and a PoSSe scale of 17,3%. The mean number of painkillers taken during the postoperative week is also lower in patients treated with the naked eye (6.8). The surgical loupes obtain the highest score in all outcomes (VAS 35.00 mm, PoSSe 22.1% and number of painkillers 8.6). The results obtained are not statistically significant.

	n	PoSSe	SD	*p-value*
Surgical loupes	18	22.1	10.5	*0.398*
Microscope	20	21.9	16.1	
Naked eye	20	17.3	9.4	

	n	No. painkillers	SD	*p-value*
Surgical loupes	18	8.6	7.6	*0.729*
Microscope	20	7.4	8.3	
Naked eye	20	6.8	4.8	

	n	VAS	SD	*p-value*
Surgical loupes	18	35.00	19.66	*0.243*
Microscope	20	30.60	26.02	
Naked eye	20	23.20	18.29	

TABLE 33 COMPARISON BETWEEN THREE TREATMENT ARMS IN NO ANTIBIOTIC GROUP

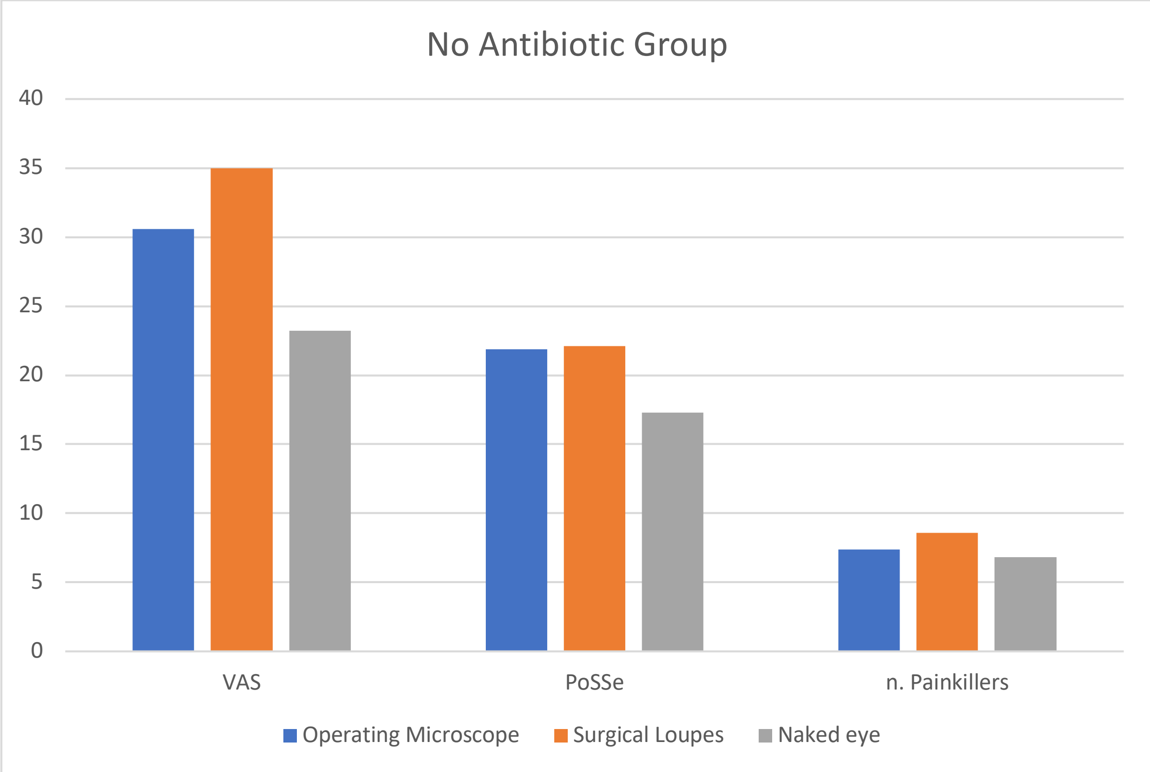


FIGURE 37 GRAPHIC REPRESENTATION OF THE COMPARISON BETWEEN THE THREE TREATMENT ARMS IN NO ANTIBIOTIC GROUP

Surgical time and magnifying systems

The duration of the interventions seems to be the same in the three methods, with a maximum average difference of 2.4 minutes. The surgical loupes achieve the best result (20.8 min), and the operating microscope is the slowest method of treatment (23.2 min), also in this case, these results are not statistically significance.

	n	Surgical times (min)	SD	*p-value*
Surgical loupes	30	20.8	9.4	*0.7347*
Microscope	30	23.2	14.7	
Naked eye	30	21.7	11.1	

TABLE 34 MEAN SURGICAL TIME IN THE THREE GROUPS.

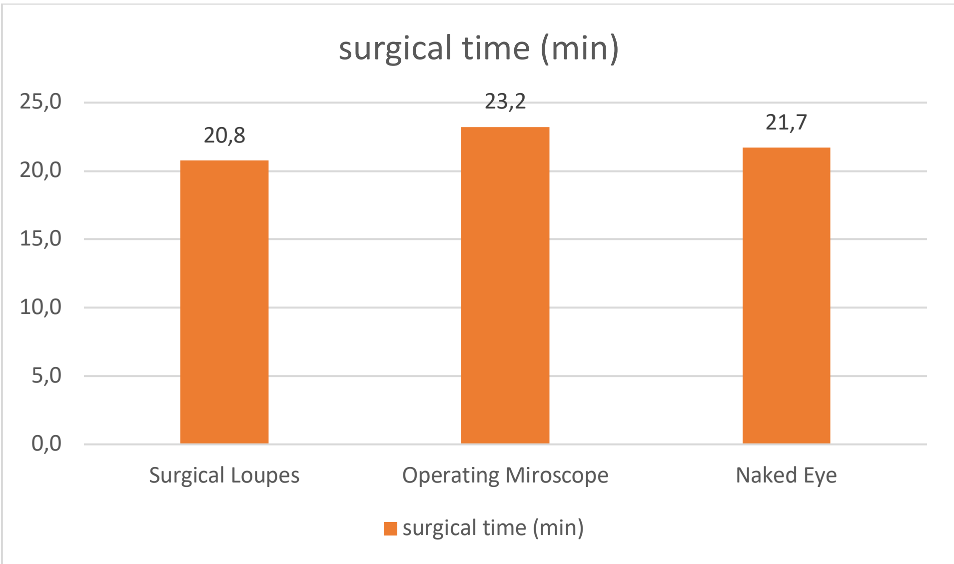


FIGURE 38 GRAPHIC REPRESENTATION OF THE MEAN SURGICAL TIME IN THE THREE GROUPS.

Postoperative complications

The complications considered in the final results are alveolar osteitis (dry alveolitis), surgical site superinfection, and patients who went to their doctor in the days following the operation due to problems related to extraction and altered sensitivity. Seven patients out of 89 experienced one or more complications (incidence 7.8%). No complications occurred in the group of patients who took antibiotic prophylaxis. Chi-square test was performed; the result obtained shows that the difference between the groups is statistically significant with a $p < 0.05$ ($p = 0.044$). All complications resolved within a week. In cases of dry alveolitis, the analgesic therapy with Nimesulide 100 mg was replaced as needed, with naproxen sodium 550 mg every 12 hours, for the following 4/5 days. In cases of superinfection of the surgical site, in addition to analgesic therapy, antibiotic treatment with amoxicillin 1 g was prescribed, 1 tablet every 8 hours for 6 days.

	Complications	No complications	tot	*p-value*
Atb	0	31	31	*0.044*
No Atb	7	51	58	
tot	7	82	89	

TABLE 35 P-VALUE, COMPLICATIONS AFTER SURGERY

Dried alveolitis is the most frequent complication (about 50% of complications), followed by patients who contacted their physician for non-specific problems. Surgical site superinfection and transient sensitivity alteration occurred only once, in the same patient.

We wanted to investigate if the antibiotic itself could influence the outcomes of the study but the results obtained were not statistically significant as shown in the table below.

	Atb	no Atb	*p-value*
PoSSe	19.3	21.6	*0.37*
No. painkillers	7.3	7.2	*0.94*
VAS	20.2	21.9	*0.12*

TABLE 36 P-VALUE, ANTIBIOTIC VS NO ANTIBIOTIC

Variables and postoperative course

The magnifying systems do not affect the postoperative course in a statistically significant way. Therefore, it was decided to investigate if there were any correlations between the pre and intraoperative variables, and study outcomes (VAS, number of painkillers and PoSSe scale).

In the antibiotic group, the variables that influence postoperative pain are smoking status ($p < 0.001$), concerning the use of painkillers, and age for both the PoSSe scale ($p = 0.004$) and the number of painkillers ($p < 0.001$). Older Patients (age group> 29) reported a worse postoperative period than younger (age ≤ 29).

In the no antibiotic group, the variables that seem to modify the postoperative course are smoking status, age and indications for extraction, gender , difficulty of the surgical intervention and duration are also statistically significant for some of the outcomes. In this group, pain occurs more in patients > 29 years old, with statistical significance for all three outcomes ($p = 0.011$; $p = 0.035$; $p = 0.019$). As well as smokers of this group of patients, they obtain a mean value of PoSSe scale that is higher than that of non-smokers, with a p-value of 0.047.

The gender appears to influence pain after extraction; in our study, women took higher amounts of painkillers ($p = 0.046$).

Extraction for recurrent infections can worsen the quality of life (PoSSe scale $p = 0.008$) and increases the number of painkillers taken in the postoperative period ($p = 0.02$) especially when compared with preventive extraction or teeth removed for periodontal disorders.

There is a direct correlation between interventions considered extremely difficult by the first operator, and VAS score ($p = 0.026$).

Finally, an increase in VAS score was also noted in interventions which lasted less than 30 minutes compared to interventions of shorter duration ($p = 0.041$)

All the results reported above are summarized in Tables 10 and 11.

		PoSSe				N antidolorifici			VAS		
variables		n	media	SD	*p-value*	media	SD	*p-value*	media	SD	*p-value*
age	≤22	8	15.0	12.0	***0.004***	3.3	3.0	***<0.001***	21.75	17.80	0.075
	23-29	16	17.8	9.7		5.8	6.0		30.19	20.48	
	>29	7	27.7	8.5		12.7	5.6		46.00	20.74	
gender	M	13	21.0	14.3	0.47	6.62	5.59	0.94	29.692	20.105	0.679
	F	18	18.1	7.7		6.78	6.76		32.944	22.254	
Smoking status	yes	3	21.8	15.4	0.68	20.33	0.58	***<0.001***	43.333	17.010	0.318
	no	28	19.0	10.6		5.25	4.45		30.321	21.354	
contraceptive	yes	5	18.6	7.8	0.88	4.20	2.77	0.33	33.400	20.477	0.837
	no	26	19.4	11.5		7.19	6.58		31.231	21.589	
Indication for	infection	3	21.9	10.2	0.50	9.3	10.2	0.46	32	26.851	0.89
removal	Periodontal disease	26	17.9	9.5		6.3	6.1		30.231	21.225	
	Prophylactic removal	1	44.1	X		8.0	X		52	X	
	Orthodontics reason	1	23.9	X		8.0	X		45	X	
	Caries	0	X	X		X	X		X	X	
	Atypical facial pain	0	X	X		X	X		X	X	
Number of roots	multiple	29	19.1	11.2	0.68	6.97	6.31	0.39	30.41	21.31	0.247
	mono	2	22.5	0.7		3.00	2.83		48.50	4.95	
	Incomplete	0	X	X		X	X		X	X	
Spatial rela tionship	distoangular	3	10.5	8.9	0.40	2.00	1.00	0.09	17.667	24.542	0.575
	horizontal	5	17.5	17.5		3.80	2.77		26.200	23.134	
	vertical	7	23.2	10.4		11.14	7.52		34.714	18.670	
	mesioangular	16	19.7	8.8		6.56	5.97		34.500	21.575	
Depth	A (high)	11	18.9	10.9	0.98	8.00	7.28	0.32	28.45	20.35	0.484
	B (medium)	14	19.7	12.3		4.86	4.07		30.00	23.44	
	C (deep)	6	18.9	8.8		8.67	7.97		41.00	16.69	
Ramus relationship/	Classe I (sufficient)	23	21.0	10.5	0.27	7.00	6.58	0.59	33.09	21.57	0.81
Space available	Classe II (reduced)	6	12.8	9.4		4.67	3.01		27.17	20.74	
	Classe III (none)	2	19.5	18.5		9.50	10.61		27.50	27.58	
Flap design	Envelope flap	30	18.9	10.8	/	6.37	6.00	/	31.07	21.26	/
	Triangular flap	0	X	X		X	X		X	X	
	Trapezoidal flap	1	32.5	X		17	X		47	X	
Bone removal	yes	31	X	X	/	X	X	/	X	X	/
	no	0	X	X		X	X		X	X	
Extraction difficulty	Elevator/forceps alone	0	X	X	/	X	X	/	X	X	/
	Ostectomy/odontotomy	1	23.0	X		5	X		45	X	
	Ostectomy + odontotomy	29	18.7	10.9		6.41	6.10		30.59	21.47	
	Extremely difficult	1	32.5	X		17	X		47	X	
Operation time	<10	1	23.0	X	0.06	5	X	0.70	45	X	0.52
	11—20	15	14.9	9.0		6.13	6.74		26.60	18.81	
	21—30	9	21.3	8.6		6.67	2.80		35.33	22.01	
	>30	6	26.7	15.1		8.50	6.38		36.17	27.26	

TABLE 37 ANTIBIOTIC GROUP: CORRELATIONS BETWEEN VARIABLES AND OUTCOMES

			PoSSe			N antidolorifici			VAS		
variables		n	media	SD	p-value	media	SD	p-value	media	SD	p-value
age	≤22	28	16.2	9.0	***0.011***	6.7	6.6	***0.035***	23.46	20.41	***0.019***
	23-29	19	21.4	11.1		5.9	5.2		29.21	18.20	
	>29	11	29.1	17.5		12.3	9.0		44.91	25.14	
gender	M	22	17.3	11.2	0.15	5.18	5.57	***0.046***	24.409	22.830	0.174
	F	36	22.2	12.9		8.94	7.44		32.472	20.926	
Smoking status	yes	11	27.0	17.0	***0.047***	8.27	6.57	0.69	28.636	17.896	0.897
	no	47	18.8	10.7		7.34	7.14		29.596	22.817	
contraceptive	yes	10	25.0	8.7	0.196	8.30	4.45	0.70	38.200	17.999	0.164
	no	48	19.4	12.9		7.35	7.43		27.583	22.271	
Indication for	infection	7	34.5	19.1	***0.008***	14.1	9.8	***0.02***	45	21.613	0.070
removal	Periodontal disease	37	18.7	9.4		7.7	6.6		27.000	20.839	
	Prophylactic removal	10	15.8	11.0		4.2	3.5		23	21.4	
	Orthodontics reason	2	14.0	10.6		1.0	0.0		24	17.7	
	Caries	2	30.1	13.5		4.0	1.4		58.0	14.1	
	Atypical facial pain	0	X	X		X	X		X	X	
Number of roots	multiple	51	20.0	12.8	0.621	7.45	6.91	0.8471	27.75	22.05	0.117
	mono	7	22.5	9.5		8.00	8.06		41.57	16.65	
	Incomplete	0	X	X		X	X		X	X	
Spatial relationship	distoangular	7	26.5	13.4	0.59	8.00	6.35	0.84	34.714	20.854	0.207
	horizontal	14	19.2	9.2		6.07	6.37		20.357	15.072	
	vertical	17	19.5	17.2		8.35	6.71		27.412	24.978	
	mesioangular	20	19.7	9.0		7.65	8.11		35.600	22.286	
Depth	A (high)	22	16.7	10.3	0.15	6.27	5.33	0.46	24.91	20.29	0.167
	B (medium)	34	23.0	13.5		8.47	7.98		33.44	22.47	
	C (deep)	2	15.5	2.0		5.00	2.83		10.50	12.02	
Ramus relationship/	Classe I (sufficient)	38	19.4	9.8	0.42	7.82	7.64	0.66	28.89	22.68	0.80
Space available	Classe II (reduced)	20	22.2	16.4		6.95	5.69		30.40	20.65	
	Classe III (none)	0	X	X		X	X		X	X	
Flap design	Envelope flap	58	X	X	/	X	X	/	X	X	/
	Triangular flap	0	X	X		X	X		X	X	
	Trapezoidal flap	0	X	X		X	X		X	X	
Bone removal	yes	58	X	X	/	X	X	/	X	X	/
	no	0	X	X		X	X		X	X	
Extraction difficulty	Elevator/forceps alone	0	X	X	0.46	X	X	0.24	X	X	***0.026***
	Ostectomy/odontotomy	4	24.01	7.14		7.50	3.42		46.50	10.50	
	Ostectomy + odontotomy	49	19.47	13.07		7.00	6.71		26.14	21.43	
	Extremely difficult	5	25.94	6.76		12.60	10.50		47.80	18.70	
Operation time	<10	6	17.6	11.8	0.71	5.83	3.82	0.76	33.50	22.23	***0.041***
	11—20	29	20.0	14.6		7.55	7.56		26.86	23.72	
	21—30	13	19.3	11.6		6.77	5.25		20.85	14.66	
	>30	10	24.3	5.8		9.40	8.93		45.50	16.75	

TABLE 38 NO ANTIBIOTIC GROUP: CORRELATIONS BETWEEN VARIABLES AND OUTCOMES.

DISCUSSION

The objective of this study was to evaluate whether the use of the magnifying system, could influence the postoperative course of a patient after extraction of a lower third molar. The period investigated, with questionnaires validated by the literature, was 7 days after the intervention. From the results obtained it is clear that the methods taken into consideration, the operating microscope, the surgical loupes with coaxial illumination and the naked eye, do not have a statistically significant influence on pain intensity (VAS), quality of life (PoSSe) or the number of painkillers taken by patients.

Furthermore, the complexity of the magnifying system does not increase the duration of the operating time; indeed, the average time of the interventions with the three magnification systems is almost comparable.

This study confirmed that an antibiotic prophylaxis with amoxicillin and clavulanic acid (1 tablet of 1 g every 12 hours, from the day before the intervention for a total of 6 days) significantly reduces the onset of complications The data obtained confirms the results reported in literature (Lodi et al., 2013), antibiotic prophylaxis reduces the risk of the onset of infectious diseases such as alveolar osteitis and surgical site superinfection, but with an NnT of about 12.

In the study, we found a 100% reduction in complications, probably due to the significant numerical differences between the two samples. In the literature, a 70% reduction in risk is reported; this data is based on a very large sample (Marcussen, Laulund, Jørgensen, & Pinholt, 2016). Despite this, because of the continuous increase of adverse reactions to antibiotics and antibiotic resistance, clinicians should carefully evaluate whether it is better to treat 12 healthy patients with antibiotics to prevent an infectious complication of simple management and rapid resolution.

In both groups of patients, a lower age corresponds to a better postoperative course, with a smaller number of painkillers taken and a lower score of PoSSe and VAS scales. This data agrees with literature, in fact several authors showed that postoperative pain and complications occur more frequently in patients over 25 years old (Chuang, Perrott, Susarla, & Dodson, 2007). This could be linked to higher surgical invasiveness, due to the complete formation of the roots and constant increases in bone density, or this could be linked to a delayed healing of the surgical site for age-dependent mechanisms. Clinical studies and literature reviews have shown that in older patients the wound healing process is altered at every stage, from the increased release of inflammatory factors in the earliest stages, to the delayed migration of lymphocytes and macrophages to the site.

It is well known that smoking is involved in wound healing, reducing blood flow to the oral tissues and inhibiting the necessary enzyme systems in oxidative metabolism and oxygen transport. We know from the literature that the use of any tobacco-containing product is associated with an increased risk of alveolar osteitis, or “dry alveolitis”. It is partly related to the vasoconstrictor effects of nicotine on small blood vessels (C. L. Cardoso, Rodrigues, Ferreira, Garlet, & De Carvalho, 2010).

Finally, in the group of patients who did not take antibiotic prophylaxis, prolonged operative times and more difficult interventions negatively influenced the VAS scale but not the other outcomes.

THE INFLUENCE OF MAGNIFYING SYSTEM ON THE QUALITY OF ADHESIVE REMOVAL IN ORTHODONTIC DEBONDING: an *in vitro* study

BACKGROUND

It has been proved that the use of an optical magnification device offers advantages in many procedures, in addition to a considerable improvement in the sharpness of the images (Perrin, Eichenberger, Neuhaus, & Lussi, 2016b) it allows a correct ergonomic posture (Carpentier et al., 2019).

Many aspects of orthodontic treatment are linked to a good vision to obtain the best results. Perfect visual conditions can help practitioners in positioning the brackets and removing composite remnants after debonding (Alencar, Nobrega, Dametto, Santos, & Pinheiro, 2017).

The removal of brackets and adhesive from the tooth surface, without traumas of iatrogenic nature, is the main objective of the current orthodontic debonding.

To date, studies in which clinical methods of magnification were used to help remove composite remnants around orthodontic brackets are quite scarce (Alencar et al., 2017).

Many studies have evaluated the amount of enamel loss, using different adhesive removal techniques (Al Shamsi, Cunningham, Lamey, & Lynch, 2007), reporting values between 7 µm and 170 µm. Compared to enamel thickness of 1500-2000 µm, this loss does not seem to be a problem. However, there is a thin superficial enamel layer 20 µm thick, the hardest and the most densely mineralized tissue, that protect the deep layers and it is removed or reduced during the remnants composite removing (Alessandri Bonetti et al., 2011).

In addition to the loss of enamel, composite residues and superficial enamel damage (such as cracks and fractures) represent two other potential problems of orthodontic debonding (Pont, Özcan, Bagis, & Ren, 2010).

Many authors agree that the use of a 12-fluted carbide tungsten burrs is the gold standard (Ahrari, Akbari, Akbari, & Dabiri, 2013) to remove flash composite, followed by a series of Sof-Lex discs and abrasive pumice cups with pumice for finishing and polishing (3M ESPE, St Paul, Minn) (Janiszewska-Olszowska et al., 2016).

A strong bond between the tooth and orthodontic device is the prerequisite for the success of orthodontic treatment.

In 1955 Buonocore carried out important innovations in orthodontic field by the use 85% orthophosphoric acid for 2 minutes to etch the enamel surface, demonstrating how this procedure significantly increased the surface exposed to the adhesive (Buonocore, 1955). This important finding paved the way for modern concepts of adhesion in dentistry.

Enamel is a strongly mineralized epithelial tissue, and it is the hardest tissue in the human body. It is composed of 95% of an inorganic matrix (hydroxyapatite) and the remaining 5% of organic substances (specific proteins such as amelogenins and peptides) and water.

After the eruption of the tooth in the oral cavity, the enamel surface remains exposed to chemical (pH changes) and physical (chewing, hygiene manoeuvers, etc.) trauma. This is an important issue; the enamel has no regenerative capacity because the ameloblasts disappear during the dental eruption. Every time there’s a trauma, the enamel cannot be repaired.

Etching the enamel surface using orthophosphoric acid at 85% leads to creation of microporosity which increases the retention of resinous materials. Acid on the enamel tissue removes the inorganic matrix and produces superficial 10-15 micron microporosities increasing roughness and consequently available bonding surface.

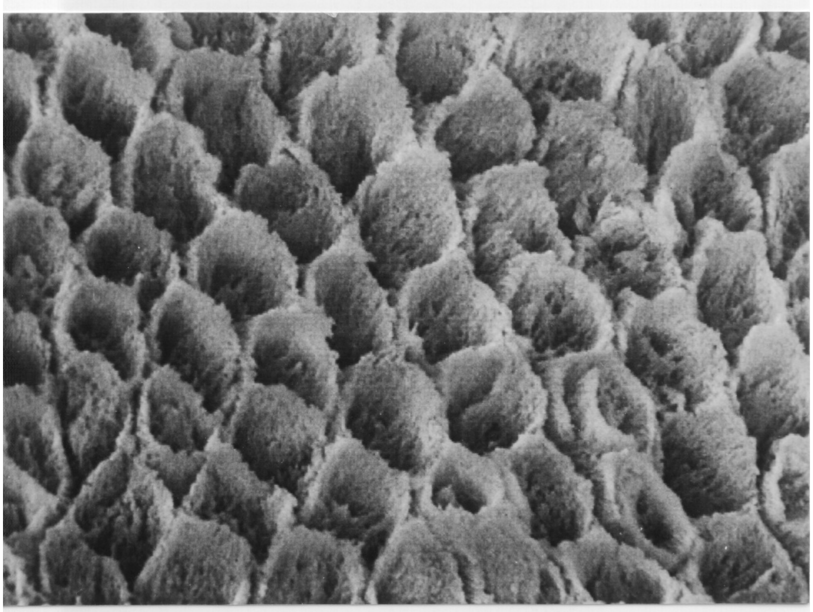


FIGURE 39 ENAMEL ETCHING SURFACE

Many studies found that 37% wt/wt phosphoric acid is the gold standard for enamel etching, and 30 seconds duration is the ideal time (Gardner & Hobson, 2001).

Etching creates an irreversible loss of enamel tissue of about 8-10 µm, creating a rough area that increases the total surface 10-20 times. Therefore, the retention between resin and enamel increases 100 times. The acid must then be carefully removed by washing and drying the teeth for at least 20 seconds.

The etched enamel will have a chalky appearance and will be more receptive to create a stable and lasting bond.

FIGURE 40 ETCHING AND DRYING OF TEETH SURFACE

Dental bonding was introduced by Bowen (Bowen, 1956) after the pioneering work on enamel preparation techniques of Buonocore (Buonocore, 1955).

The adhesive is a mixture (two-steps or one-step self-etching) of monomers that can bind to the hydrophilic surface of the tooth. In this way, we can create the same hydrophobic surface of the composite resin allowing the positioning of the brackets (Transbond PLUS Color Change Adhesive, 3M Unitek, Monrovia-California).

The modern brackets, introduced by Angle in 1927, are orthodontic devices consisting of a base and a body. There is a slot, in which the wire is housed and different retention systems according to the type of bracket (with lugs for anchoring the ligature or self-binders).

The base is the part involved in adhesion; it has a variable shape in order to obtain a perfect fit with the surfaces of the teeth. There are two categories of brackets: metallic, steel (iron-chromium-carbon steel alloy) or nickel-titanium and aesthetic ones (ceramic). Undercuts on the base of the brackets guarantee a strong mechanical bond.

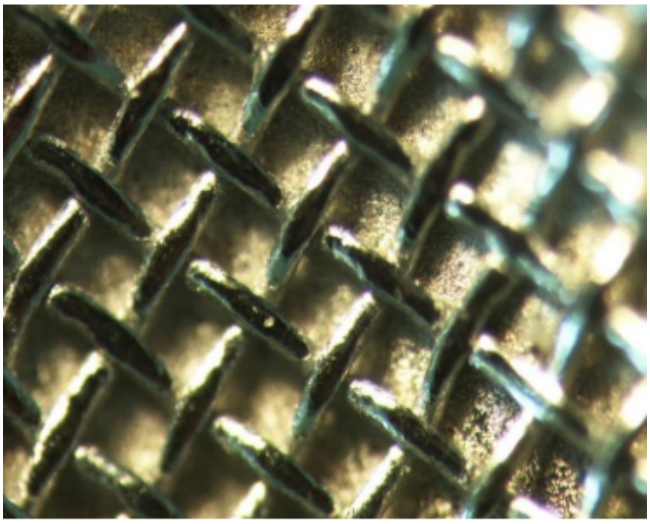


FIGURE 41 MESH BASE DESIGN AT X40 MAGNIFICATION (Ahangar Atashi, Sadr Haghighi, Nastarin, & Ahangar Atashi, 2018)

After active orthodontic treatment, brackets are mechanically debonded, and residual adhesive must be mechanically removed, since resin remnants accumulate dental plaque and might discolour the surface of the teeth.

Currently, no technique allows removal of the composite remnants without any damage to the enamel surface. The underlying reasons are acid etching resulting in resin infiltration into the enamel, and hardness of the enamel (about 5 in the Mohs scale) lower than the abrasive materials used (quartz, aluminium, carbon steel, zirconium oxide 7, and tungsten carbide 8) (Grocholewicz, 2014).

Efforts are made to minimize the loss of the external enamel layer, because it is the hardest and richest in fluoride. Moreover, the enamel surface should be left as smooth as possible after debonding, since deep scratching is not polished through the years by brushing teeth.

Various methods to debond metallic and ceramic brackets have been described in literature, including the use of special debonding pliers, ultrasound or laser application, electrothermic debonding, special instruments, and the use of bonding materials presenting thermo-expandable microcapsules to facilitate debonding. All the methods allow us to reach the same clinical result but from the patient's pain perspective the use of LODI instrument is associated with lower levels of pain and discomfort.

FIGURE 42 DEBONDING METHODS USED. A LIFT-OFF DEBONDING INSTRUMENT (LODI). B STRAIGHT CUTTER (SC). C HOW PLIER (HP). D BRACKET REMOVAL PLIER (BRP) (Pithon, Santos Fonseca Figueiredo, Oliveira, & Coqueiro, 2015)

During bracket removal, bond failure can occur at the adhesive-enamel or the adhesive-bracket interface (adhesive failure), or within the adhesive (cohesive failure); generally, a combination of adhesive and cohesive failure (mixed failure) takes place (Zanarini et al., 2013).

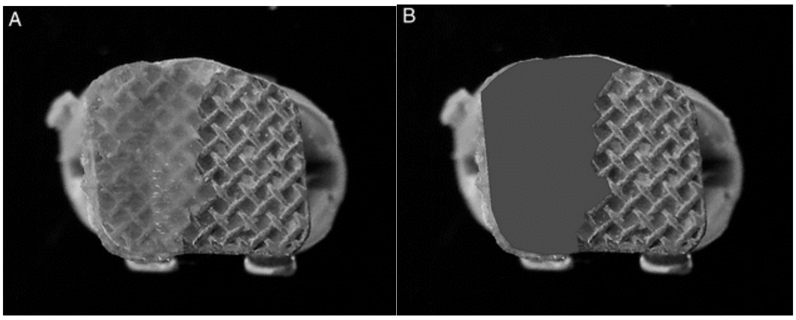


FIGURE 43 REPRESENTATIVE EXAMPLE OF THE BRACKET-BASE REMNANT-AREA MEASUREMENT. (A) A BRACKET SHOWING SOME REMNANTS. (B) THE REMNANT AREA DETECTED WITH THE USE OF IMAGE J. (Zanarini et al., 2013)

When adhesive failure between the adhesive resin and the enamel surface occurs, a certain amount of enamel loss is almost inevitable because of the micromechanical bond between the composite resin bonding agent and the acid-etched enamel (Alessandri Bonetti et al., 2011).

The side effects that most often occur following removal of brackets are:

• enamel cracks

• enamel prism detachment

• enamel fractures

To determine the amount of resin remaining on the surface of the teeth the Adhesive remnant index (ARI) score is commonly used and is described by Artun and Bergland in 1984. The ARI ranges from 0 to 3, with 0 indicating that there is no adhesive remaining on the tooth, 1 indicating that there is <=50% of the adhesive remaining on the tooth, 2 indicating that there is >50% of adhesive remaining on the tooth, and 3 indicating that there is 100% of the adhesive remaining on the tooth. The Enamel Damage Index (EDI), is a measure that derives from the surface roughness index described by Howell and Weekes in 1990 which includes the following categories: grade 0, smooth surface without scratches and perikymata might be visible; grade 1, acceptable surface with fine scattered scratches; grade 2, rough surface with numerous coarse scratches or slight grooves visible; and grade 3, surface with coarse scratches, wide grooves, and enamel damage visible to the naked eye (Alessandri Bonetti et al., 2011).

The final treatment of debonding is the cleanup. In this case, the removal of the resin is obtained by a multiblade burr using a high-speed handpiece with water cooling, followed by disks Sof-lex (3M ESPE, Seefeld, Germany) using a low-speed handpiece with air-cooling. Studies in literature show that the aid of a magnification system significantly reduces the enamel damages and effectively removes the adhesive residuals from the surfaces (Bernardi, Continenza, & Macchiarelli, 2018).

In order to evaluate the adhesive residuals, the use of silicone impression has been generally employed. Nowadays, we can use intraoral scanners to take the intraoral impression. T hanks to optical technologies, scanners work without contact with the object studied, such as confocal microscopy (Trios-3Shape), coherent optical light tomography (E4D-D4D Technologies LLC), active triangulation (Cerec Bluecam-Sirona), interferometry (DPI-3D-Dimensional photonics International Inc.), and active wavefront sampling (TrueDefinition scanner-LA VA 3M). Intraoral scanners acquire image data (Cerec Bluecam; E4D) or video (Trios; TrueDefinition Scanner).

FIGURE 44 INTRAORAL SCANNERS

It’s possible to obtain a 3D digital reconstruction with an STL data file. STL files use linked triangle facets to describe the geometric surface of a three-dimensional object. In this same way we can evaluate the volume of a composite residual.

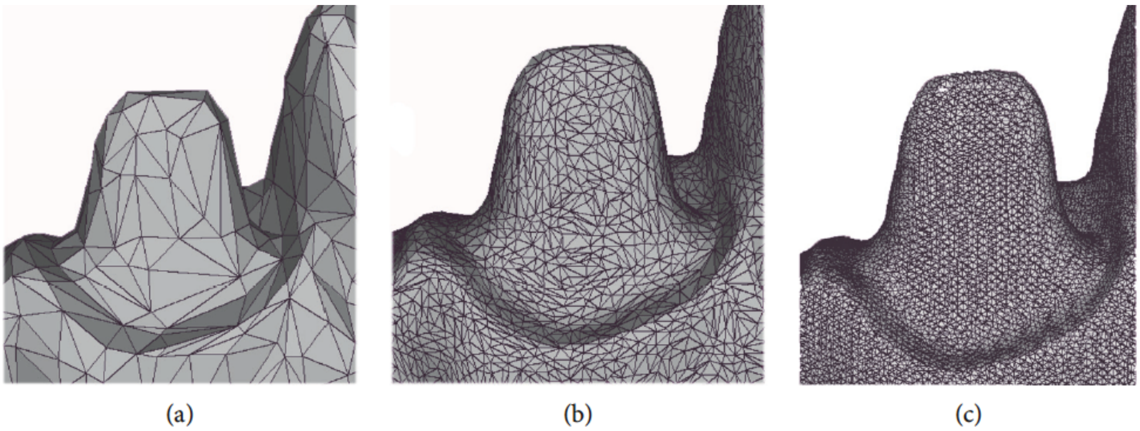


FIGURE 45: COMPARISON OF STL DATA. (A) LOW DENSITY. (B) MEDIUM DENSITY. (C) HIGH DENSITY

MATERIALS AND METHODS

The present study aims to investigate the effects of using different magnifying systems for removal of composite residues and in the prevention of iatrogenic enamel damage. The data will be analyzed with an intraoral scanner and photograph analyses.

For this study, 27 permanents teeth extracted at the Ospedale Santi Paolo e Carlo, Unità Operativa Complessa Odontostomatologia II were used. The teeth were extracted for periodontal reasons or for dental-periodontal problems that did not make them recoverable. The selected teeth should not have any signs of caries, cracks or macroscopic fractures that are noticeable by naked eye on the coronal portion.

The teeth were randomly divided into 3 groups named A, B and C.

In group A the debonding procedures were performed without the aid of a magnification system, in group B surgical loupes were used (4x 450mm EyeMag Pro F from ZEISS and coaxial lighting system) and in group C an operating microscope (OPMI Movena S7). Each tooth was photographed and scanned with the intraoral scanner CS3600-Carestream before bracket placement (T0), post bracket positioning (T1), after removal of bracket (T2) and after debonding (T3).

Sample preparation (T0)

The teeth were initially cleaned and polished with non-fluoridated pumice paste and rubber cups for 10 seconds, then rinsed with water and dried. The samples were embedded in a block of transparent self-curing acrylic resin up to the level of the enamel cementum junction and stored in distilled water at 37 ° C.

Bracket positioning (T1)

Each tooth was etched with 37% orthophosphoric acid (Scotchbond Etchant 7423, 3M ESPE) for 30 seconds, washed for 30 seconds and then dried. The light-curing adhesive (Transbond XT Primer, 3M Unitek) was applied with a micro brush with circular and light-curing movements (VALO LED Curing Light; light output, 395-480 nm) for 30 seconds to 1 m from the tooth surface. The brackets (DAMON™ 3MX, Ormco) were applied and positioned using adhesive cement (Transbond XT, 3M Unitek) and the excesses around the edges of the brackets were removed with the aid of a periodontal probe. The brackets were then light-cured mesially and distally for 20 seconds in both directions. The samples were stored in water at 37 ° C for 7 days before removing the brackets.

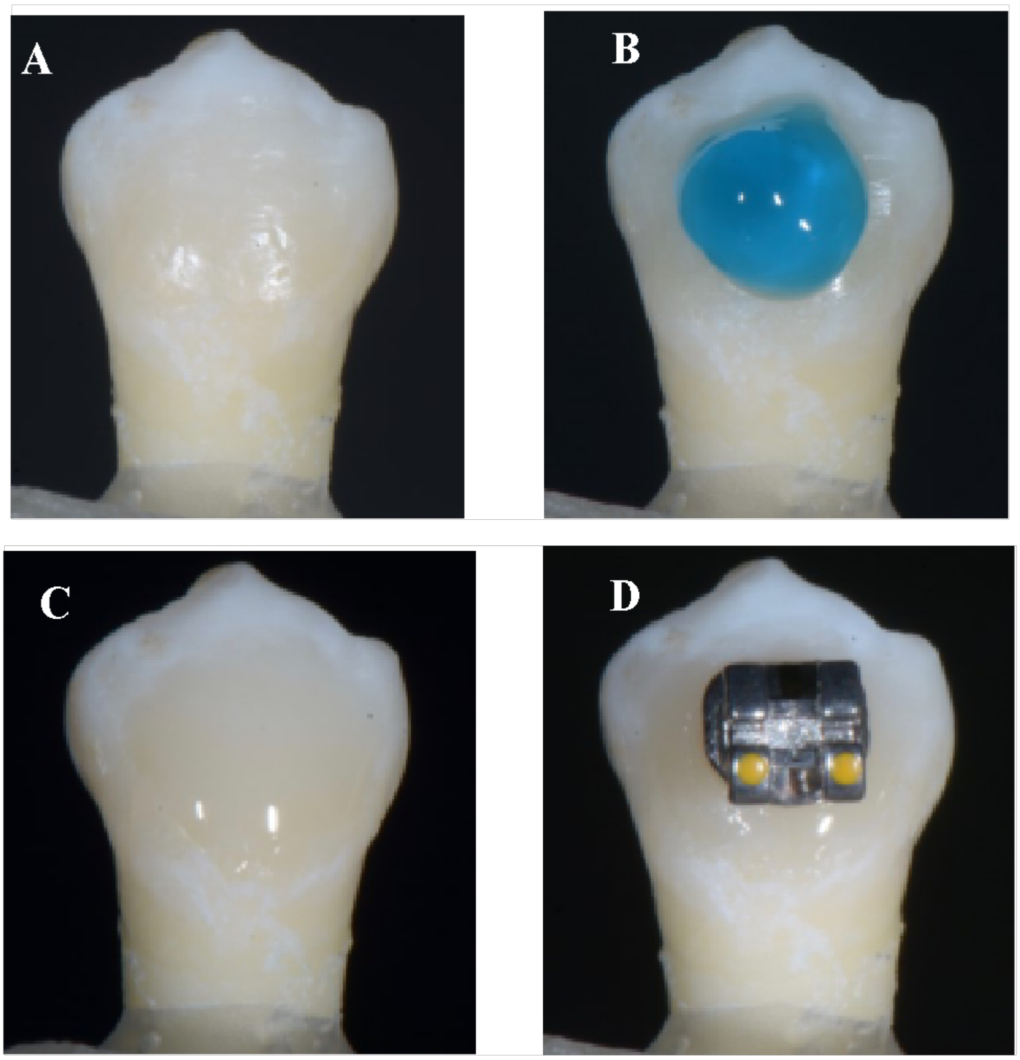


FIGURE 46 SAMPLE PREPARATION (A) TOOTH SURFACE CLEANED AND POLISHED WITH PUMICE PASTE (B) ETCHING SURFACE (C) APPLICATION OF RESIN ADHESIVE ON TOOTH SURFACE (D) BRACKET POSITIONING

Bracket removal (T2)

A debonding forceps was used for the bracket removal, deforming the base and limiting the torsional movements to minimize the risk of damage of the enamel surface. For the evaluation of residual composite after debonding, we used the ARI (Adhesive Remnant Index) , introduced by Artun and Bergland in 1984:

• 0 - all the residual composite remains on the base of the bracket

• 1- more than half of the residual composite remains on the base of the bracket

• 2- less than half of the residual composite remains on the base of the bracket

• 3- there is no composite on the base of the bracket

The bases of the brackets were examined both with the naked eye and photograph at high magnification. The ARI score was calculated with an image processing program (ImageJ open source image analysis software version 1.44o for Macintosh, National Institutes of Health, Bethesda, Md) using photographs of the base of the brackets to determine the percentage of the residual composite compared to the total area of the base itself (ARI bracket).

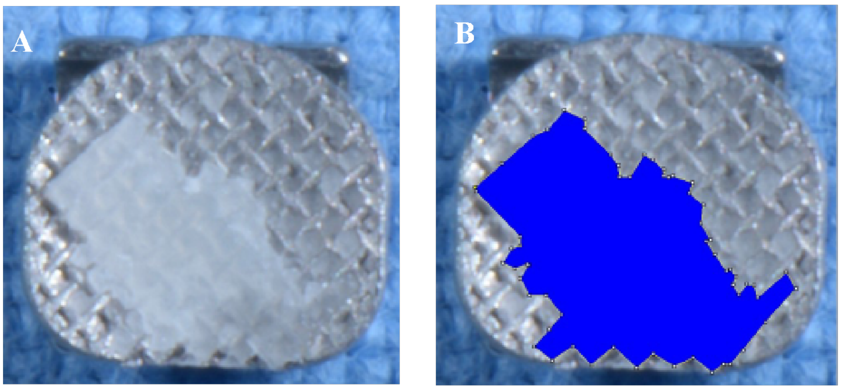


FIGURE 47 BASE OF BRACKET AFTER REMOVAL (A) AMOUNT OF RESIDUAL COMPOSITE (B) ARI BRACKET PROCESSED WITH IMJ

Tooth	Adhesive area/bracket base	%	ARI bracket (ImageJ)
1	60949/736431	8,28	2
2	21219/709897	2,99	2
3	848350/772026	109	0
4	326975/773662	42,26	2
5	112693/780119	14,45	2
6	63626/773917	8,23	2
7	0/773917	0	3
8	33054/766216	4,13	2
9	211178/601316	35,12	2
10	61097/693464	8,81	2
11	38053/777788	4,89	2
12	68774/729629	9,43	2
13	14684/759602	1,93	2
14	29135/695630	4,19	2
15	46618/767824	6,07	2
16	10369/695966	1,49	2
17	781928/677533	115,4	0
18	74213/788137	9,41	2
19	29823/692130	4,31	2
20	0/729291	0	3
21	25550/713267	3,58	2
22	532614/802718	66,35	1
23	63970/685257	9,34	2
24	0/477054	0	3
25	0/486005	0	3
26	32600/750125	4,29	2
27	771328/772493	99,85	1

TABLE 39 ARI BRACKETS VALUES

Clean up (T3)

The visible composite residuals were removed from the surface of the teeth with a high-speed multi-blade tungsten carbide bur (40,000 rpm). A series of extra-thin Sof-Lex disks (3M Dental, St Paul, Minnesota) with descending granulometry (medium-fine and extra-fine) was used for the finishing and polishing of the underlying enamel. The composite residuals removal and restitution ad integrum of the enamel surface (as in T0) was verified by visual inspection.

The time for the clean-up procedures were recorded in seconds with a digital chronometer. All procedures (bonding, debonding and cleaning) have been performed by the same operator.

The data were compared using the ANOVA (Analysis of Variance). A post-hoc test was performed to highlight the differences between groups.

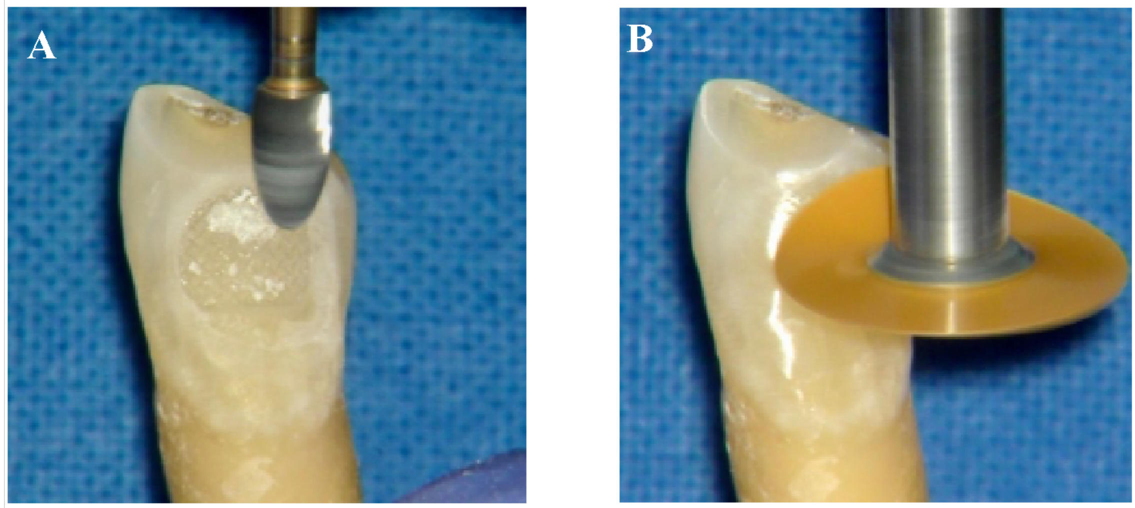


FIGURE 48 ADHESIVE REMOVAL (A) MULTI-BLADE TUNGSTEN CARBIDE BURS (B) SOFT-LEX DISKS

FIGURE 49 S SOFT-LEX DISKS SERIES

At the end of the polishing phase, each surface was etched again for 30s, rinsed for 10s and then dried to evaluate macroscopically, the presence of any adhesive residues on the tooth's surface.

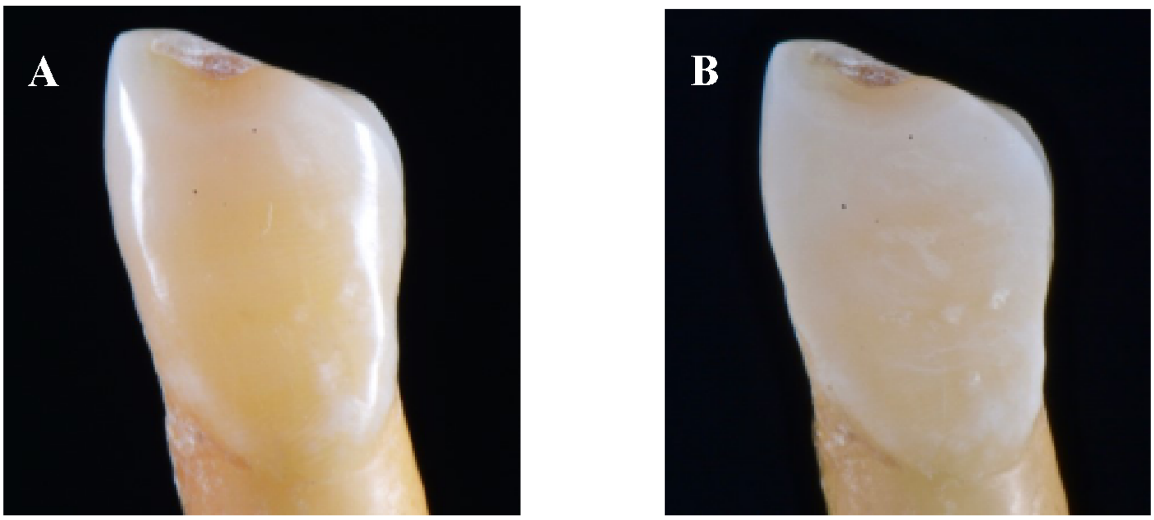


FIGURE 50 (A) TOOTH SURFACE AFTER POLISHING (B) TOOTH SURFACE AFTER ETCHING

Superficial analysis

All scans data were acquired with the intraoral scanner CS3600-Carestream before bracket placement (T0), post bracket positioning (T1), after removal of the bracket (T2) and after debonding (T3). The data were exported in STL (Standard Tessellation Language) format and exported to the MeshLab software.

To determine the changes on the enamel surface where the brackets were placed, images after removal of the bracket and after clean-up (Figure 50 A and B) were superimposed on the first acquisition, using all surfaces of the tooth unchanged as reference areas for the alignment. The alignment algorithm in MeshLab minimizes the average square difference between the first acquisition and the subsequent scans. We have eliminated all the STL data above the enamel cementum junction.

The resolution of Carestream intraoral scan is 0.05 mm. It's impossible to achieve higher accuracy because there is a systematic error by acquiring the same surface (everything that is less than 0.05 mm is unmeasurable).

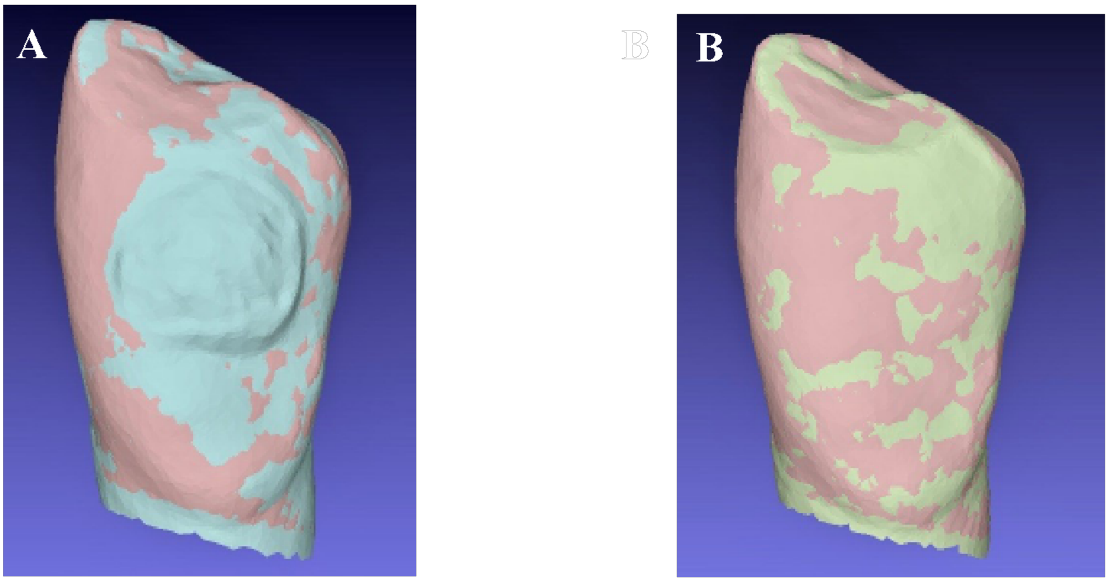


FIGURE 51 (A) MATCHING BETWEEN T1 AND T2, (B) MATCHING BETWEEN T1 AND T4

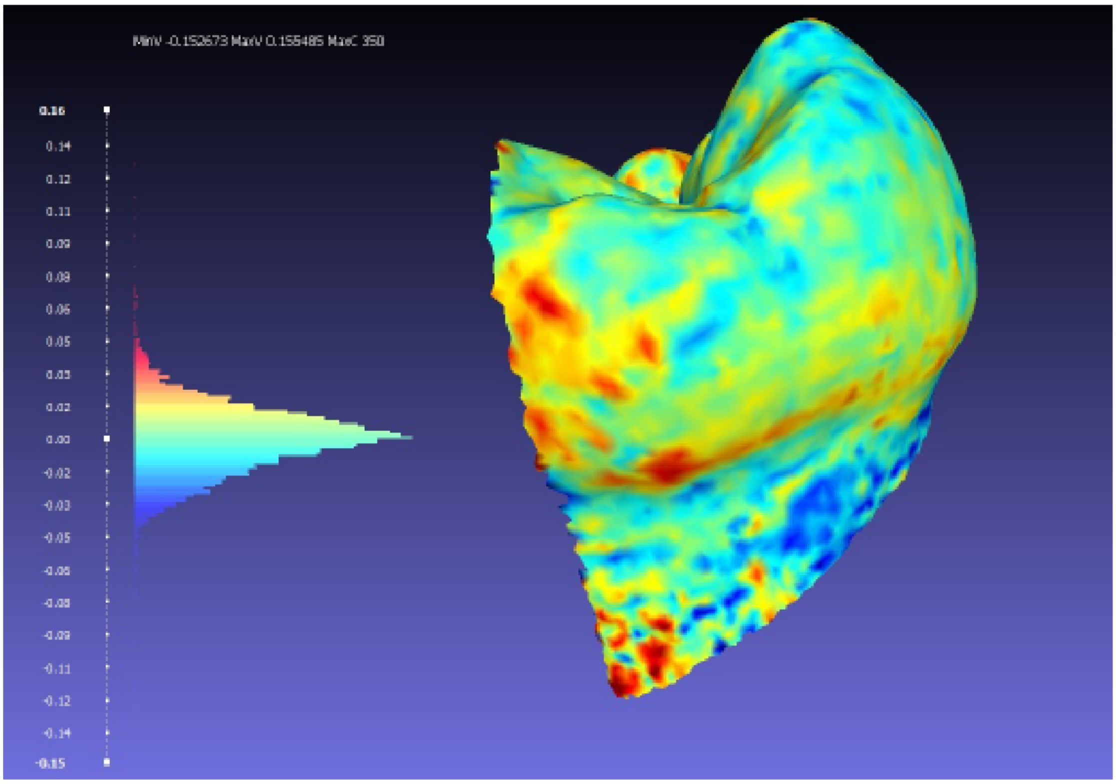


FIGURE 52 GAUSSIAN ERROR ACQUISITION

By superimposing the scan data, the software calculates the surface alterations. The images show the superficial modifications through a color mapping (Quality Mapper) that facilitates the evaluation of the surface.

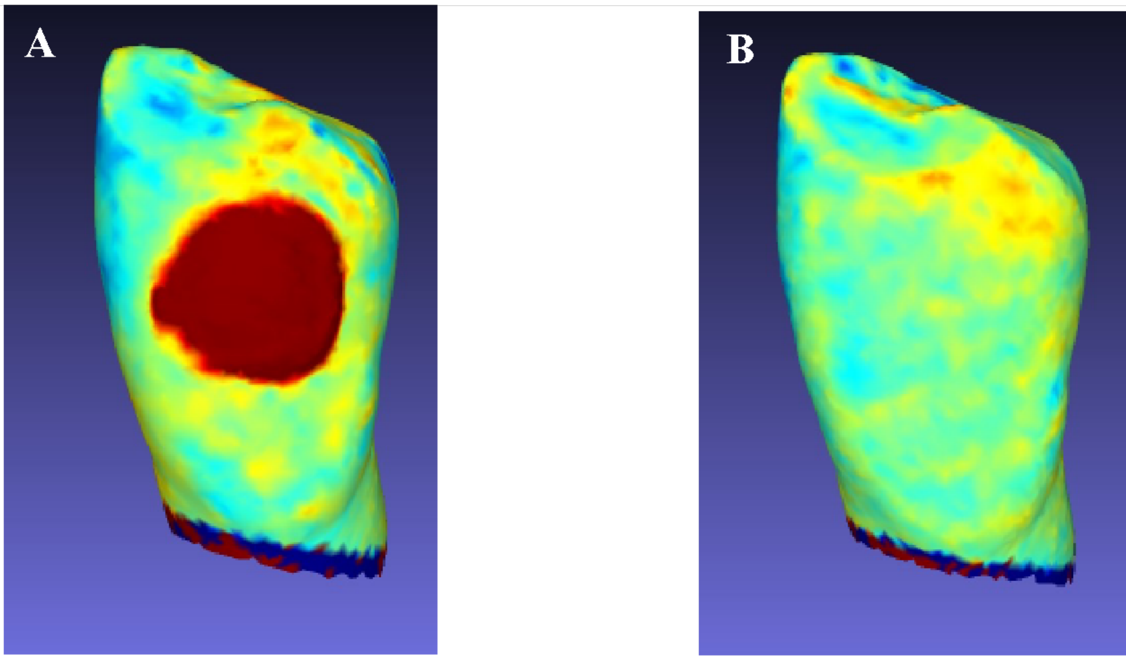


FIGURE 53 SURFACE QUALITY MAPPER (A) AFTER BRACKET REMOVAL (B) AFTER CLEAN UP

We also calculated the volumes of each acquisition comparing T0, T2 and T3 through the MATLAB software, version R2018a.

	T0	T2	T3	(T2-T0)	(T3-T0)
1	387,0448761	387,4776758	387,0466358	0,432799627	0,00175965
2	381,4226415	382,0897415	381,574472	0,66710002	0,151830488
3	305,3238332	305,3469203	305,4604101	0,023087135	0,13657686
4	261,1853974	261,9567413	261,2390494	0,771343842	0,053651968
5	513,5680561	513,5755386	513,6013004	0,007482485	0,033244284
6	150,0802847	150,5859924	150,1339202	0,505707702	0,053635446
7	131,7267026	132,220745	131,8357069	0,494042397	0,109004364
8	381,8392666	382,4797783	381,8594076	0,640511676	0,02014096
9	378,0374835	378,4390315	378,0650866	0,40154798	0,027603121
10	233,0755782	233,3345531	233,155948	0,258974819	0,08036979
11	243,3433115	243,6950182	243,3947865	0,351706662	0,051475013
12	468,730579	469,3773596	468,7482538	0,64678062	0,017674773
13	261,915312	262,03471	262,078191	0,119397977	0,162878963
14	260,5763059	260,9406725	260,7382579	0,364366629	0,162878963
15	282,8008189	283,7012119	282,9202777	0,90039295	0,119458784
16	189,7246509	190,1479135	189,8792559	0,423262647	0,15460506
17	257,7416383	257,8368367	257,7459336	0,09519837 7	0,00429534
18	458,9843137	459,8881431	459,1103433	0,903829316	0,126029511
19	240,5673556	240,8377577	240,7346508	0,270402065	0,167295175
20	497,0520406	497,3275117	497,1492415	0,275471086	0,097200952
21	439,1036796	439,5283575	439,2043971	0,424677871	0,100717447
22	329,8356752	330,1289693	329,8410243	0,293294075	0,005349097
23	281,4605503	281,9965543	281,5610382	0,53600404	0,100487978
24	480,4614843	481,0366161	480,5735886	0,575131791	0,11210425
25	276,4424445	276,5018528	276,4576629	0,059408281	0,015218407
26	114,750741	115,5780673	114,9232001	0,827326331	0,172459152
27	347,1493319	347,712681	347,1786781	0,563349118	0,029346198

Group A Group B Group C

TABLE 40 F ADHESIVE VOLUME (MATLAB)

RESULTS

Adhesive Remnant Index (ARI)

The image analysis with the ImageJ processing program showed that the most frequent type of detachment is the mixed form [ARI1 + ARI2] with an evident prevalence of the ARI 2.

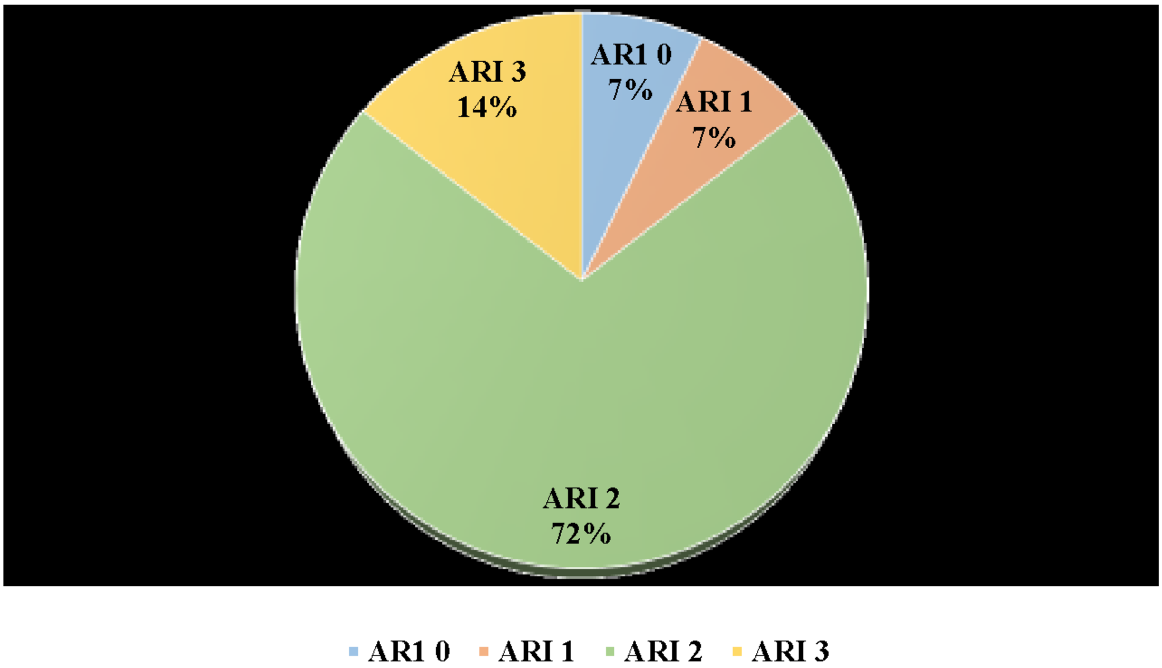


FIGURE 54 ARI PERCENTAGE DISTRIBUTION

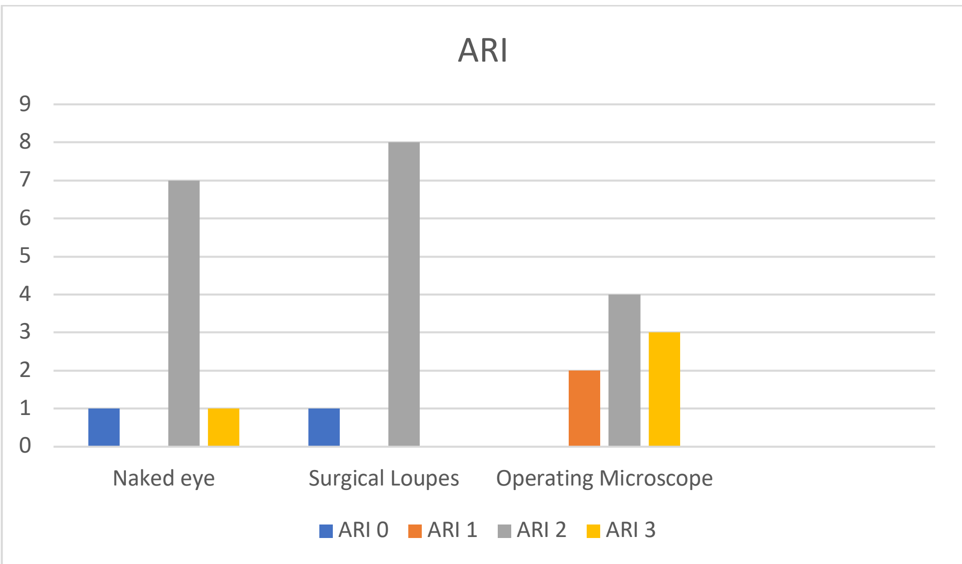


FIGURE 55 ARI DISTRIBUTION IN THE THREE GROUPS OF TREATMENTS

Post debonding composite residues have an average volume of 0.43 mm^3 (± 0.26 mm^3). The average volume was indicated below:

ARI score 0 (two samples) 0.06 mm^3,

ARI score 1 (two samples) 0.43 mm^3

ARI score 2 (18 samples) 0.49 mm^3

ARI score 3 (4 samples) 0.35 mm^3

Operating times

The table below shows the average time required for the clean-up in each group. The procedures performed without a magnification system were faster than those performed with a microscope or surgical loupes. To determine the P-value the ANOVA test was applied.

Magnification system	Average time of clean up (sec)	P-value
Group A **naked eye** (n=9)	121.7+/- 16.8	0.0023
Group B **surgical loupes** (n=9)	157.1+/- 23.1	
Group C **operating microscope** (n=9)	139.7+/- 15.9	

TABLE 41 CLEAN UP AVERAGE TIME (SEC)

In this study, the difference between procedures performed with the naked eye and those performed with surgical loupes are statistically relevant (post-hoc test).

Post-hoc test	P-value
Group A vs Group B	0.0016
Group A vs Group C	0.1283
Group B vs Group C	0.1452

TABLE 42 COMPARISON BETWEEN THE THREE GROUPS

Adhesive residuals

We evaluated the post-etching dental surfaces and compared it with the percentages of post-clean-up residual composite for each of the three types of magnification.

The macroscopic observation of the post-final etching dental surfaces has highlighted composite residues in 44% of the samples (12 elements). The clean-up procedures performed without the aid of a magnifying system show composite residues in a higher number of elements compared to the same procedures performed with the aid of magnification systems. There are post clean up composite residues on 6 elements in the group of no magnifying systems, on 4 elements in the surgical loupes group and on 2 elements in the operating microscope group. There is no statistical difference between the procedures performed with the naked eye and those performed with magnification systems.

Magnification system	No. teeth with composite residual	No. teeth without composite residual	p-value
Group A (n=9)	6	3	0.165
Group B (n=9)	4	5	
Group C (n=9)	2	7	

TABLE 43 TEETH WITH O WITHOUT COMPOSITE RESIDUALS

With the analysis of the images acquired through the ImageJ processing program, we determine the percentage of residual composite. Figure 55 shows the average percentage of post-clean-up residual adhesive in each of the three groups of treatment. The percentage of residual adhesive is greater in the group without magnification.

Magnification system	Average percentage of residual composite	p-value
Group A (n=9)	11.84 +/- 10.52	0.0022
Group B (n=9)	2.13 +/- 3.85	
Group C (n=9)	0.62 +/- 1.69	

TABLE 44 AVERAGE PERCENTAGE OF COMPOSITE RESIDUAL

The difference between the procedures performed with the naked eye and those performed with magnification systems is statistically significant. There are no relevant differences between the two different magnifying systems.

Post-hoc test	P-value
Group A vs Group B	0.0108
Group A vs Group C	0.0033
Group B vs Group C	0.8745

TABLE 45 COMPARISON BETWEEN THE THREE GROUPS ON COMPOSITE RESIDUALS

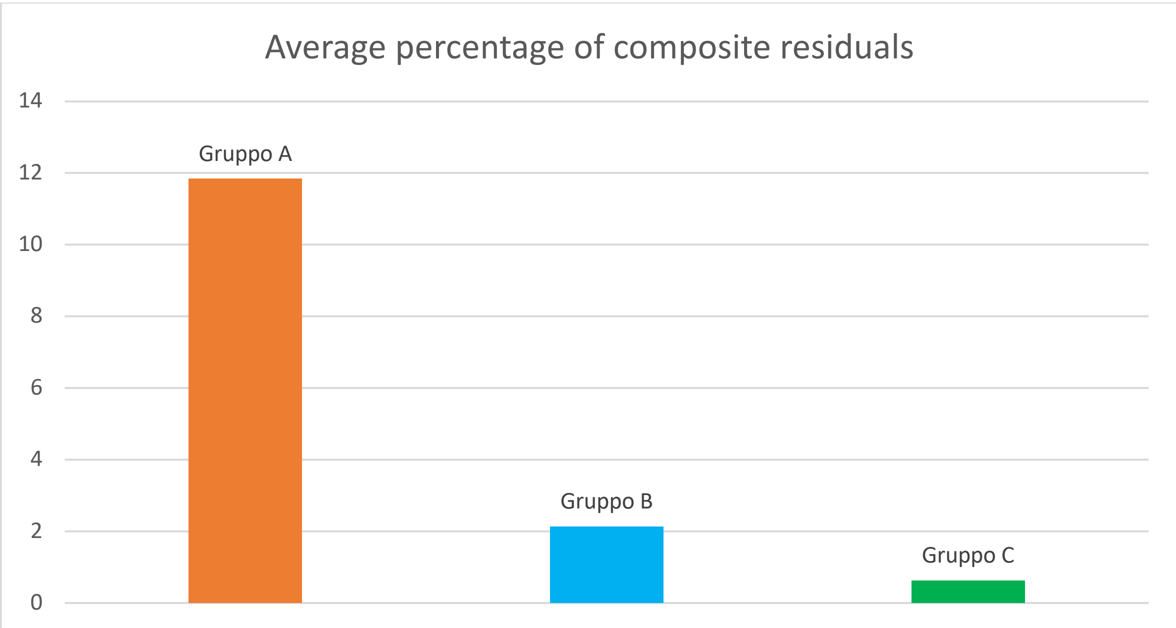


FIGURE 56 AVERAGE PERCENTAGE OF COMPOSITE RESIDUALS

The table below displays the volumetric differences obtained comparing T0 and T4 for each of the three types of magnification. There is no statistical difference between the procedures performed with the naked eye and those performed with magnification systems.

Magnification system	Average volumetric differences	P-value
Group A (n=9)	0.084 +/- 0.06	0.9411
Group B (n=9)	0.079 +/- 0.07	
Group C (n=9)	0.089 +/- 0.06	

TABLE 46 AVERAGE VOLUMETRIC DIFFERENCES

Magnification system	Maximum volume	Minimum volume
Group A (n=9)	0.16729518	0.01521841
Group B (n=9)	0.172459152	0.00175965
Group C (n=9)	0.15460506	0.017674773

TABLE 47 MAXIMUM/MINIMUM COMPOSITE RESIDUALS VOLUME

For each type of magnification group we recorded the maximum and minimum volume obtained at T4, corresponding to the amount of post-clean-up adhesive residue.

DISCUSSION

In our study, we decided to use multi-blade tungsten carbide burrs to remove the post-debracketing residual composite. Polishing was performed by a series of extra thin Sof-Lex discs with decreasing grain size. The goal is to apply a mini-invasive and atraumatic protocol on dental tissues (Ulusoy, 2009). Aggressive treatment could lead to irreversible enamel damage such as deep cracks, increased dentinal sensitivity and cosmetic damage (Rodríguez-Chávez, Arenas-Alatorre, & Belio-Reyes, 2017). Despite these considerations, there are no guidelines for debonding in the literature. Some professionals prefer to use diamond burs to reduce working time, but independent of the experience and careful use, there is a high risk of damage to the dental surface. Several studies report the use of tungsten carbide burs, followed by a finishing system (L. A. M. Cardoso, Valdrighi, Vedovello Filho, & Correr, 2015). The use of tungsten carbide multi-blade cutters (12 blades) mounted on a high-speed handpiece in association with decreasing grain size disks did not appear to report any clinically relevant Soft-Lex damage to the enamel. It is also known how the risk of damage to the enamel decreases with increasing amount of adhesive remaining on the tooth after detaching the bracket (Sigilião et al., 2015). At the time of debonding, it is desirable to obtain a fracture to the adhesive-bracket interface (adhesive fracture) or inside the adhesive itself (cohesive fracture) to preserve the integrity of the enamel.

The data obtained in our study, with the observation of high magnification brackets and the subsequent analysis of ImageJ images, shows how the type of detachment is more frequent in a mixed form (ARI1 + ARI2) with prevalence of ARI 2.

Another factor we took into account is the time for the clean up using the different types of magnification. The procedures performed without a magnification system are on average faster than those performed with the aid of magnification. More specifically , there is a statistically significant difference between the procedures performed with the naked eye and

those performed with magnifying glasses. This result can be explained by greater attention and accuracy in removing the residual composite from the operator when using magnification systems thanks to the greater visibility and discrimination of the detail.
According to the literature (Baumann, Brauchli, & Van Waes, 2011), in our study the difference in percentage of residual adhesive is statistically significant between debonding performed with magnification systems than procedures performed with the naked eye. There are no differences between the two magnifying systems.
The intraoral scanner did not seem appropriate to assess any damage to the enamel surface.
This study was conducted *in vitro* as most of the literature on this topic. We didn’t take into account important parameters such as saliva, oral hygiene, temperature , pH changes and the effect that all these factors can have on the enamel over time. The reparative power that saliva can exert on superficial enamel lesions is known, thanks to the precipitation of calcium ions in a saturated environment. Based on the results of our study, it becomes necessary to investigate the presence of enamel damage in the case of debonding with clinical trials on patients. Only in this way can we give a clinically relevant value to our findings.

CONCLUSION

This study investigated the effectiveness of the microscope in dental practice in terms of posture improvement for the operator and clinical advantages for the patients.

We know that a critical issue for dental workers is the onset of musculoskeletal diseases (WMSDs) (Hayes et al., 2009). Long sitting hours, constrained posture, awkward positions and repetitive movements expose the operator to muscular fatigue and stress. Injuries can occur from a single event, or cumulative trauma and may cause muscle pain, particularly in the neck and back. WMSDs in dentistry considerably contribute to sick leave, reduced productivity and leaving the profession (B Valachi, 2008).

Guidelines emphasize an upright posture for the dental clinician, stabilization of the trunk, minimal reach to obtain equipment, close accessibility to the oral cavity, and the ability to change position frequently to improve access. Authors defined the correct angle degree to avoid dangerous joints position that could lead to the onset of WMSDs (Partido, 2017).

To evaluate the exposure of individual workers to ergonomic risk factors associated with upper extremity MSD, a rapid upper limb assessment (RULA) method was developed. The RULA was designed for easy use without the need for an advanced degree in ergonomics or expensive equipment (McAtamney & Corlett, 1993). We decided to use this validated method to evaluate the operator posture, but we presented a novel approach for upper limb posture assessment based on the tracking of a set of planar markers placed on the clothes of the worker (Marcon et al., 2018). Thanks to this non-invasive approach, we were able to follow exactly all the movements with no need of an external observer.

We compared the microscope with no magnification (the naked eye) and surgical loupes. One of the most clear variables of a dental practitioner is the bending and twisting of the neck and trunk to access the oral cavity. Magnification systems contrast those movements, allowing for the ability to maintain an upright posture and improve visual acuity.
In literature, many studies treat this topic, and results confirm posture and clinical improvements (James & Gilmour, 2017). The best results are obtained from the microscope, thanks to the high quality of lens and illumination.

We performed 90 wisdom teeth extractions, and we collected all postural and clinical data. The analysis we performed can be easily integrated into classical ergonomics assessment tools like RULA. We found a significant reduction of neck bending in magnification groups, in particular for those interventions performed with the microscope. The difference ranges from 31 to 0 degrees, but the final RULA score was not affected by this value. A dentists' work is a caring profession that exposes to WMSDs, as shown in many reviews (Hayes et al., 2009). The onset of WMSDs, from a posture point of view, depends on many movements and positions of the wrist, lower and upper arm, trunk and static posture. The importance of neck bending seems to be low if all other variables have had a bad score.

If we consider the results obtained in motion history represented in fig.12, we can see many differences between the posture of the dentist in three groups of intervention. A big range of movements in the naked eye group and an almost static position in the microscope. It seems that the same operator performed two different types of intervention. These differences didn't emerge from the RULA score worksheet. We can conclude that this type of analysis is not acceptable when a very precise method is used. We developed a new approach for posture assessment, more precise and accurate, and we have had 3D data of the whole body, which can discriminate differences of one degree. We need long term studies conducted on many dentists (male and female) and a new method of posture data analysis to define the correlation between upper limbs posture and WMSDs accurately.

The differences emerged from our study are evident but we can't say if there is a clinical relevance. We don't know if there is any real problem that could affect the operator's health in relation to neck bending or twisting. We are setting up another study to evaluate superficial electromyography of muscles involved in posture maintenance. Pre, intra and post-operative evaluation can tell which muscles are stressed in our daily work. Moreover, we can assess if the use of magnifying systems can reduce muscular stress.

We collected clinical data to evaluate whether the use of magnification systems can improve the postoperative course in patients undergoing lower wisdom tooth extraction. From the results obtained it is clear that the methods taken into consideration, the operating microscope, the surgical loupes with coaxial illumination and the naked eye, do not have a significant influence on pain intensity (VAS), quality of life (PoSSe) or the number of painkillers taken by patients. Furthermore, the complexity of the magnifying system did not increase the operating time.

We chose the lower third molars for extraction because, in a short time in our clinical practice, we were able to find many patients that meet the inclusion criteria. Moreover, we wanted to test magnification systems in fields of dentistry different from endodontics in which a microscope is generally used. Even if data had no statistical significance, on the other hand microscope didn't affect the operating time. Despite common perceptions, the use of the microscope in oral surgery didn't slow down the intervention.

Finally, we decided to test the microscope potential in debonding. There are few studies in the literature on this topic. In our research, the procedures performed without a magnification system are on average faster than those performed with the aid of magnification. In particular, there is a statistically significant difference between the procedures performed with the naked eye and those performed with surgical loupes. This result can be explained by greater attention and accuracy in removing the residual composite from the operator when using magnification systems. The microscope and surgical loupes were slower but got the best results in removal of composite remnants. The intraoral scanner that we used to evaluate the teeth surfaces does not appear useful to discriminate damage to the enamel.

The microscope is an excellent magnification system, and offers the best results in terms of visual acuity, illumination, depth of field, clinician neck posture. It requires a relatively flat learning curve and main advantages are not only the possibility to reach high magnification, but also that it quickly generates a pre-, per-, and post-operative iconography of the treatments. It could be an important learning instrument and all these advantages could be applied not only to endodontics but can also be expressed in other areas too. Potential applications could be greater than previously believed.

However, many findings have not yet been confirmed in the literature and further analysis on a larger study sample may be conclusive.

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I thank you for your part in my life journey.

I hope I can always deserve your company and your support.

“No human mind can be 100% wrong. Or, we might say, nobody is smart enough to be wrong all the time. *And that means, when it comes to deciding which approaches, methodologies, epistemologies, or ways or knowing are "correct," the answer can only be, "All of them." That is, all of the numerous practices or paradigms of human inquiry — including physics, chemistry, hermeneutics, collaborative inquiry, meditation, neuroscience, vision quest, phenomenology, structuralism, subtle energy research, systems theory, shamanic voyaging, chaos theory, developmental psychology—all of those modes of inquiry have an important piece of the overall puzzle of a total existence that includes, among other many things, health and illness, doctors and patients, sickness and healing.”*

K. W.

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