

From the Department of Operative Dentistry and Periodontology,  
Ludwig-Maximilians-Universität München,  
Director: Prof. Dr.med.dent. Reinhard Hickel

# **Results from two different studies in Endodontology and dental traumatology**

Thesis for the attainment of the degree  
Doctor of Philosophy (Ph.D.)  
at the Faculty of Medicine at the  
Ludwig-Maximilians-Universität München,



Submitted by  
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from  
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München  
28.06.2019

With permission from the medical faculty of  
Ludwig-Maximilians-Universität München

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Dean:	Prof. Dr. med. dent. Reinhard Hickel
Date of oral defense:	30.09.2019



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I further declare that the submitted thesis or parts thereof have not been presented as part of an examination degree to any other university.  
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Place, date

**Mohamed Mahmoud Nabieh Eltair**

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Signature doctoral candidate



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March 2017



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# List of Abbreviations:

BC	Bioceramic
CI	Confidence intervals
SD	Standard deviation
SEM	Scanning electron microscopy
WD	Working distance
WHO	World Health Organization
TCIs	Traumatic crown injuries
(DMF)T	(Decayed, Missing, Filled) Teeth; in permanent dentition
ICDAS	International caries detection and assessment system
STROBE	The Strengthening the Reporting of Observational Studies in Epidemiology

# Chapter 1

## **Publication List**

## *CHAPTER 1 PUBLICATION LIST*

### **1.1 Ph.D. Topics**

The topic of my Ph.D. thesis was “Results from two different studies in Endodontology and dental traumatology”

As part of my Ph.D. requirements, it was considered to work on the following primary topics:

**Project 1. Evaluation of the interface between gutta-percha and two types of sealers using scanning electron microscopy (SEM).**

**Project 2. Prevalence of traumatic crown injuries in German adolescents**

### **1.2 Authorship:**

1-Eltair M, Pitchika V, Hickel R, Kühnisch J, Diegritz C. Evaluation of the interface between gutta-percha and two types of sealers using scanning electron microscopy (SEM). Clin Oral Investig. 2018;22(4):1631-9.

2- Eltair M, Pitchika V, Standl M, Lang T, Krämer N, Hickel R, Kühnisch J. Prevalence of traumatic crown injuries in German adolescents. Clin Oral Investig. 2019 (Online)

# Chapter 2

## **Introduction**

## *CHAPTER 2 INTRODUCTION*

### **2.1 Project 1**

#### **Evaluation of the interface between gutta-percha and two types of sealers using scanning electron microscopy (SEM).**

The main objective of root canal treatment therapy is to produce a bacterial-free root canal system. Achieving this aim is produced by cleaning and shaping of root canal and formation of a tight seal between the sealer and gutta-percha and/or dentin interfaces; therefore root canal filling play an important role in preventing the ingress of bacteria and their toxins (1, 2).

##### **2.1.1 Bioceramics (BC) in endodontics, a new era?**

Basically, a great variety of different sealers are available for endodontic use. The traditional root canal sealers have many disadvantages like that they are dimensionally instable, do not provide a bond between the core material and they lack the antibacterial properties (3-6).

Recently calcium silicate-based endodontic filling materials have been introduced in the market because of their adhesive properties, insolubility to tissue fluids and at the same time provide a high biocompatibility (2, 6). These products are available in North America as EndoSequence BC Sealer™ (Brasseler USA Dental LLC, Savannah, GA) and is known in Europe as TotalFill BC sealer (FKG Dentaire, La Chaux-de-Fonds, Switzerland). Both type of sealers are similar in chemical composition (calcium silicates, zirconium oxide, tantalum oxide, calcium phosphate monobasic and fillers).

According to manufactures, it is recommended to use BC sealers in combination with BC impregnated gutta-percha. They claimed that chemically binding or mechanically

## CHAPTER 2 INTRODUCTION

impregnating a BC coating over the surface of gutta-percha cones so that the chemistry and surface energy of the coating are similar to those of the sealer will improve both the adaptation and bond strength between the sealer and gutta-percha (7, 8). In this project, it was hypothesized that there would be no difference between different materials or techniques of obturation in terms of adaptability and sealing ability.

### 2.1.2 Materials and methods

*Study sampling.* In this project, an In-vitro study was performed to evaluate the interface between the root canal filling materials with root canal dentin. The study samples comprised of 72 caries-free, straight single rooted mandibular premolars. All teeth were randomly divided into six groups according to the obturation technique and the type of gutta-percha or sealer (Table 1).

*Sample Preparation and obturation.* Decoronation of each sample at the cemento-enamel junction was performed using a water-cooled diamond disc (IsoMet 1000, Buehler Ltd., Lake Bluff, IL, USA) to obtain a standardised root length of 12 mm. The canals were prepared by Mtwo rotary files to a size #40/04 (VDW GmbH, München, Germany) which were mounted on a VDW Gold motor (VDW GmbH, Munich, Germany) following an appropriate irrigation protocol. Then smear layer is removed using 3 mL ethylenediaminetetraacetic acid (EDTA, 17%) for 1 min followed by 3 mL NaOCl (3%) and then rinsed with 5 mL saline for 1 min and dried with paper points. Subsequently all the prepared samples were obturated as illustrated in table 1.

*The use of an indirect method for scanning the samples.* After obturation, the samples were kept and incubated for 7 days at 37 °C in a phosphate-buffered saline solution (pH =

## *CHAPTER 2 INTRODUCTION*

7.4) for optimal setting of the sealer (9). Each specimen was firmly attached onto an acrylic plate adapted to the IsoMet cutting machine. Each root was sectioned perpendicularly to its long axis at 3, 6 and 9 mm from the apex to obtain disk-shaped sections from the coronal, middle and apical regions with the aid of the built-in micrometre, obtaining equal sections (n = 216). Then the specimens were cleaned and air dried and then examined with a Zeiss Axioplan light microscope (Carl Zeiss, Oberkochen, Germany) to confirm the integrity of the specimens and that the filling are free of any dislodgement. Finally, an indirect method to create a replica of samples for SEM analysis was done. Replicas of the slices were fabricated immediately using a self-curing epoxy material (Agar Scientific Ltd., Essex, UK) and then stored in a Hybaid Shake 'N' Stack thermo-oven (HBSNSR110, Thermo Electron Corporation, Massachusetts, USA) for 2 days at 60 °C. This indirect method was preferred over the direct one because the potential damage of the specimens due to over-drying was avoided (10)

*SEM imaging and image analysis.* The obtained replicas were then mounted on aluminium stubs (Plano, Wetzlar, Germany), gold palladium-sputtered (Polaron Range SC 7620 Sputter Coater, Quorum Technologies Ltd., Ashford, UK), and examined with an SEM microscope (Zeiss Supra 55 VP, Carl Zeiss AG, Oberkochen, Germany), which was adjusted at approximately 10 kV. one photomicrograph was taken of the whole root canal area at a magnification between  $\times 35$  and  $\times 1000$ , depending on the sample size and the working distance (WD) of the SEM. Subsequently, analysis of images were done by ImageJ software (ImageJ 1.5 1a, Wayne Rasband, National Institutes of Health, USA) to accurately measure the area of the gutta-percha, sealer and gaps between the interfaces of sealer and gutta-percha or sealer and dentin.



## *CHAPTER 2 INTRODUCTION*

*Regression model for statistical analysis.* All descriptive and explorative analyses were performed using R version 3.2.1 (R Core Team, 2015). Descriptive statistics were calculated for all outcomes. The outcomes were not normally distributed under Shapiro-Wilk tests. Pairwise comparisons between the canal section levels, the technique of obturation, the type of gutta-percha and the type of sealer were analysed using the Mann-Whitney U test. An unadjusted linear regression model was developed for each outcome of interest versus the group. Furthermore, to explore the influence of any confounders, a multiple linear regression model was established for each outcome. A two-tailed  $\alpha$  significance level of 0.05 and a 95% confidence level were used for all analyses.

### **2.1.3 Results and conclusion**

A significant difference was found between the coronal and apical sections with respect to the interfacial gaps between the sealer and the gutta-percha. When adjusting for other influencing factors in the linear regression models, different variables significantly influenced the sealing ability and adaptation of the root canal filling, it was found that the type of gutta-percha and sealer significantly affect the percentage of the interfacial gaps. Interestingly, conventional gutta-percha was associated with a lower percentage of interfacial gaps between gutta-percha and sealer ( $p < 0.001$ ) and between sealer and dentin ( $p = 0.04$ ), whereas the AH Plus sealer showed more gaps between sealer and dentin compared with the BC sealer ( $p = 0.04$ ).

## **2.2 Project 2:**

### **Prevalence of traumatic crown injuries in German adolescents**

## *CHAPTER 2 INTRODUCTION*

### **2.2.1 Traumatic crown injuries**

Traumatic crown injuries (TCIs) account as one of the most frequent dental problems following dental caries and periodontal diseases that mostly affect children and young adults (11).

### **2.2.2 Epidemiology of TCIs:**

Up to twenty-five percent of all school children experience dental trauma making up approximately 5% of all body injuries (12). In literature, the prevalence of TCIs in the permanent dentition was found to be approximately 25%. This percent might be influenced by several factors including different age groups, gender, different classifications of TCIs and the methodological tool used (13-15). Further looking at the available literature, it was found that the evaluation of the results was relied on either clinical examination and/or dental questionnaires. Despite that these questionnaires act as a complementary method in the assessment of these injuries, they may be subjected to memory bias which might lead to unrealistic data. The lack of standardization in methodology and classification of TCIs among various studies leads to a variation in the prevalence rate and make the comparison between different countries not possible (12, 16, 17). Moreover, it was found that boys are more affected than girls (18) and that the upper incisors teeth being the most influenced ones (18-20).

Information in literature regarding TCIs in many European countries are lacking. In Germany, to our knowledge, there are limited up-to-date data available on TCIs (21). Therefore, the present study determined the prevalence of TCIs in 10-, 12- and 15-year-old children in two different population-based cohorts in Bavaria, Germany.

## CHAPTER 2 INTRODUCTION

### 2.2.3 Materials and methods

Data from three population-based studies performed between 2006 and 2015 in Bavaria aged 10, 12, 15-year-olds were used. These studies include two Munich birth cohorts (GINIplus and LISA) and regular dental school examinations in southern Bavaria (LAGZ). The local ethics committee approved all studies.

Written consent for the dental examinations was obtained from all participating children and their legal guardians. All procedures in these studies were performed in accordance with the ethical standards of the institutional research committee and the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The recommendations of the STROBE guidelines for observational studies were applied for reporting (22).

*Study population of 10- and 15-year-olds.* Cross-sectional data sets were collected at two time points from the same participants at the ages of 10 and 15 years. Details of the study's background, recruitment strategy, common inclusion and exclusion criteria and follow-up schedules are described extensively elsewhere (23-28).

*Study population of 12-year-olds.* A sample of 12-year-old age school children in 107 secondary schools was investigated during regular dental examinations of children who attended the public dental preventive program in Bavaria. The examination took place from October 2015 to June 2016. The calibration done include (non-) cavitated carious lesions and dental trauma, and potential differential diagnoses, e.g., molar-incisor hypomineralization, erosion or fluorosis and were published elsewhere (28-30).

*Dental scoring:* Registration of caries, restorations and trauma-related restorations using the tooth and surface-related methodology for the permanent dentition were done (31).

## *CHAPTER 2 INTRODUCTION*

Non-cavitated carious lesions were also recorded at a tooth and surface-related level according to the ICDAS criteria (32). Following the WHO classification, TCIs were recorded (31).

*Statistical analysis.* Descriptive and comparative data analyses were performed using Microsoft Excel 2010 and the statistical package R (<http://www.r-projekt.org>). Twelve-year-olds (LAGZ) were compared with the 10- and 15-year-olds (GINIplus/LISA) using Mann-Whitney-U tests. The 10- and 15-year-olds in the GINIplus/LISA cohorts represented a paired dataset, which were compared using the Wilcoxon Signed Rank test. All analyses were performed using 95% confidence intervals and a two-tailed significance level of 0.05.

### **2.2.4 Results and conclusion**

The prevalence of TCIs among 10- and 12-year-old children was 6.3%. Boys were more frequently affected than girls in the 12- and 15-year-old groups. Significant differences were found between 10- and 15-year-olds and between 12- and 15-year-olds for traumatized teeth. The most frequently affected teeth were the maxillary incisors with a total proportion of 87.5% of all traumatized teeth (Figure 1).

Regarding dental caries, it was found that the proportion of affected children increased with age. The DMF index showed significant differences between 10- and 12-year-olds. Comparison of the participants who were present in the 10- and 15-year-olds groups revealed a significant difference.

## *CHAPTER 2 INTRODUCTION*

### **2.3 Objectives of the thesis**

- **Project 1:**

Assessment of the advantages of BC materials in the field of endodontics in addition to evaluating the interface between root canal sealer and gutta-percha and/or dentin interfaces

- **Project 2:**

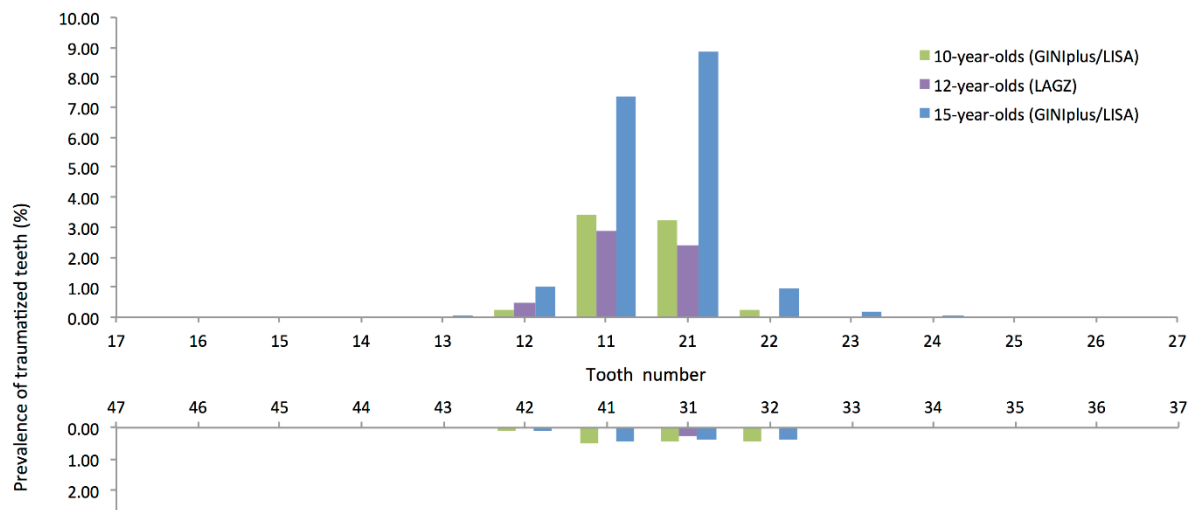
Evaluation of the prevalence of TCIs among the German adolescents as well as evaluating different study designs and methodologies as an impact on the results outcome.

## CHAPTER 2 INTRODUCTION

Table 1: Overview of the study groups, obturation techniques and materials.

Group	Obturation technique	Gutta-percha	Sealer
1	Single cone	Total fill BC	Total fill BC
2	Lateral condensation	Total fill BC	Total fill BC
3	Single cone	Conventional	Total fill BC
4	Lateral condensation	Conventional	Total fill BC
5	Single cone	Conventional	AH Plus
6	Lateral condensation	Conventional	AH Plus

Fig. 1 Proportion of traumatized teeth in relation to the overall number of investigated permanent teeth. The graph shows the polarization of traumatized teeth in the permanent incisors in the three study groups.



# **Chapter 3**

## **Discussion**

## *CHAPTER 3 DISCUSSION*

As conducting a scientific research depends substantially on many essential factors, the importance of the study design represents the most critical step for its accomplishment.

Each topic included in this thesis has a different study design:

Project 1: In-vitro material testing.

Project 2: Cross-sectional observational study from prospective cohort aspect.

### **Project 1:**

Basically, the project started in a systemic and organized way from defining a question or formulating a hypothesis to drawing conclusions about data. Mandibular premolars teeth were selected and divided randomly into 6 different groups according the obturation materials and the techniques used.

One of the challenges we faced in this project was the samples preparation. SEM was used to determine the marginal adaptation and sealing ability of root canal sealer to gutta-percha and/or dentine interfaces on the various levels of sectioning. Mostly, the conventional preparation of biological samples before SEM examination may be associated with many artefacts as cracks and separation of the filling material from the surrounding tooth structure as a result of the high vacuum associated with SEM (10) This problem was avoided by using an indirect method of examination by performing an impression using vinyl polysiloxane impression material to create a replica immediately using a self-curing epoxy material and subsequently stored in an oven at 60 °C for 2 days for SEM analysis.

Evaluation of the results underwent an appropriate statistical testing method. All the statistical work was supervised by a qualified statistician. Univariate analyses were



## *CHAPTER 3 DISCUSSION*

performed, but all conclusions were not based on the results from these analyses, e.g in this project regression models were performed where plausible and the associations were adjusted for relevant confounders.

### **Project 2:**

In the second project, an extensive 2 cohorts studies in Munich were included. We used the cross-sectional data sets that were collected at two time points from the same participants at the ages of 10 and 15 years. Moreover, a stratified random sample from the Bavarian Workgroup for Oral Health were chosen from 12 years old children.

The focus was directed in this project on the true prevalence rate of traumatic tooth injuries in epidemiological studies in adolescents. It was found that detailed information for several European countries in the existing literature is unavailable. Up to our knowledge, there are limited up-to-date data available on TCIs in Germany (21), therefore the objective of this topic was to evaluate the prevalence of TCIs among the German adolescents through performing only clinical examination on the study participants without encountering dental questionnaires. Despite the importance of these questionnaires as a complement to the evaluating data, it could be subjected to memory bias. For that reason, dental questionnaires were excluded.

The limitation of this study was the difficulty to perform dental radiographs or vitality tests on the affected teeth. Furthermore, the healed luxation injuries were not included in our results. That is why the true prevalence rate might be underestimated.

### **Submitting the work**

Finally submitting our work was done complying to the author's guidelines. All the

### *CHAPTER 3 DISCUSSION*

manuscripts were written strictly following the guidelines of these journals, both with respect to the content and format. Before finally submitting the manuscript, we also sent the articles to be edited by third-party English editors to improve the quality of the language and the writing style. In case of a manuscript being rejected by a journal, the manuscript was edited in accordance to the next preferred journal's guidelines and resubmitted.

# **Chapter 4**

## **Summary**

## *CHAPTER 4 SUMMARY*

This thesis consisted of two projects that were performed during the period of PhD in oral sciences after acquisition of enough practicing.

### **We can conclude the following:**

- The use of bioceramic root canal sealer has an impact on the obturation outcome as it resulted in less interfacial gaps. However, using the conventional gutta-percha instead of bioceramic gutta-percha has a favourable outcome. Furthermore, there was no difference between using the single cone and lateral condensation techniques. Moreover, more studies should be performed to evaluate the benefits of these new materials.
- The prevalence of TCIs in German adolescents was found to be generally low and was influenced by the study methodology used. The upper incisors teeth were the mostly affected teeth. Furthermore, boys were more concerned than girls.

# **Chapter 5**

## **Publication 1**

Clin Oral Invest (2018) 22:1631-1639  
DOI 10.1007/s00784-017-2216-x

# **Chapter 6**

## **Publication 2**

Clinical Oral Investigations

<http://doi.org/10.1007/s00784-019-02974-1>

Published online: 19 June 2019

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I am grateful to my friend and colleague Vinay Pitchika for his contribution in the statistical part of both projects.

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I would like to thank my parents; whose love and guidance are with me in whatever I pursue. They are the ultimate role models. Most importantly, I am very grateful to my loving and supportive wife who provided me with unending inspiration.

Finally, I would like to thank the participants of all the projects, without whom this thesis would not be possible

# **Chapter 7**

# **Appendix**

# Mohamed Eltair

Dentist and Dental Researcher

## PROFILE:

A post-graduate with 12 years of experience in the field of Endodontics.

## WORKING EXPERIENCE:

2017 to date:

### Dentist

Clinic Kim Grabosch, Munich.

2014 to date:

### PhD in Oral Sciences

School of Dentistry, Ludwig-Maximilians-Universität München (LMU Munich), Germany.

2006 to 2014:

### Dentist and Assistant lecturer

Department of Endodontics, Future University in Egypt.

2012 to 2014:

### Endodontist

Sharqawy Dental Clinic, Cairo

## CHAPTER APPENDIX

2010 to 2012:

### **Endodontist**

Elite Dental Clinic, Cairo, Egypt

2005 to 2010:

### **Dentist**

Helaly Dental Center, Cairo, Egypt



## **EDUCATION**

2014 to date:

### **PhD Oral Sciences**

School of Dentistry, Ludwig-Maximilians-Universität München (LMU Munich), Germany.

#### *Research topics:*

Project 1. Evaluation of the interface between gutta-percha and two types of sealers using scanning electron microscopy (SEM).

Project 2. Prevalence of traumatic crown injuries in German adolescents.

2007 to 2012:

### **Master in Endodontics**

Faculty of Oral and Dental Medicine, Cairo University, Egypt.

#### *Research topics:*

Effect of mechanical preparation with RaCe and Protaper systems on surface topography, cleanliness and microleakage of prepared canals.

2000 to 2005:

### **Bachelor in Dentistry**

Very good, 11. Average rating,  
Faculty of Dentistry, Mansoura University, Egypt.



## Conferences and courses

- 2019**                      **48. Jahrestagung der Arbeitsgemeinschaft Dentale Technologie e.v**
- 2019**                      **23. Jahrestagung des Landesverbandes Berlin-Brandenburg im DGI e.v**
- 2017**                      **Acaemy of Dental Materials conference in Nuremberg, Germany**
- 2016**                      **Regenerativ Medizin**  
Klinik für Allgemeine, Unfall-, Hand- und Plastische Chirurgie, München.
- 2015**                      **SAF Endosystem**  
Reinigung, Aufbereitung und Spülung in einem Arbeitsschritt ( Poliklinik für Zahnerhaltung und Parodontologie, Ludwig Maximilians-Universität, München, Germany.
- 2013**                      **Advanced Endodontic Course**  
Future Endodontic Microscopic Center, Cairo, Egypt.
- Basic Contemporary Endodontic Course**  
Future Endodontic Microscope Center  
(Assistent to Prof. Ahmed Abdelrahman)
- 2007**                      **Future University First International dental conference**  
“Excellence in Dentistry”, Cairo, Egypt.



## Aktivitäten

### Swimming Championships

- 1996-•2001**                      Seven gold medals at the National Swimming championships in Egypt in the years 1996-2001.
- 1996**                      Swimming championship in Darmstadt, age group 13 > 4 bronze medals.