



TOOTH WEAR

THE QUINTESSENTIAL CHALLENGE

Debora R. Vilaboa
Beatriz R. Vilaboa
Jose Manuel Reuss
Debora Reuss

 QUINTESSENCE PUBLISHING



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A CIP record for this book is available from the British Library.

ISBN: 978-1-78698-120-2

QUINTESSENCE PUBLISHING DEUTSCHLAND

Quintessenz Verlags-GmbH
Ifenpfad 2-4
12107 Berlin
Germany
www.quintessence-publishing.com

Quintessence Publishing Co Ltd
Grafton Road, New Malden
Surrey KT3 3AB
United Kingdom
www.quintessence-publishing.com

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Editing: Quintessence Publishing Co, Inc, Batavia, IL, USA

Layout, Production and Reproduction: Quintessenz Verlags-GmbH, Berlin,
Germany

Printed and bound in Croatia by Grafički zavod Hrvatske d.o.o.



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Foreword

Why is Tooth Wear the Quintessential Challenge?

The Ancient Greeks believed a certain type of air could be found in the upper section of heaven, a type of air that was purer and more splendid than the air inhaled by mere mortals. This dazzling substance, or essence, inhaled by the Gods was known as ether.

Aristotle classified ether as the fifth natural element. To the four natural elements that had previously been identified by the Ionic philosophers—earth, water, air, and fire—Aristotle added a new, completely different element in his theory of nature.

When faced with the traditional four elements that made up the sublunar world, corruptible and subject to change—and given to imperfect, rectilinear movements—ether, the element that occupied the superlunar layers of the cosmos, the element from which the celestial spheres housing the planets and stars were made, was incorruptible, moving eternally and perfectly in circles, presenting characteristics that brought them closer to the divine.

Medieval philosophers gave ether the Latin name of “quintessence” for its aforementioned characteristic of being the fifth element that made up the Universe. The concept of quintessence gained significant importance in alchemy both in the Middle Ages and in the Early Modern Period.

In traditional alchemy, quintessence came to be identified as the Philosopher’s Stone (elixir of life), an essence that could transform any metal into gold. Alchemists searched for quintessence on Earth, but, believing that they would find very limited quantities here given its celestial origins, they mainly tried to find a formula to obtain ether by combining the other elements.

They had hoped to use quintessence as medicine in the form of an elixir. Given the purity and the divine quality of quintessence, alchemists believed that by taking the elixir an individual would remain free of any type of impurity and sickness, and they would even become young again (rejuvenate). Quintessence began to be identified with a spiritual energy that could unite and dissolve the other four elements; the soul of the world. Paracelsus maintained that quintessence was the element that would bring new life to the body and the soul. Inspired by the archaic Pythagorean doctrine, alchemists considered quintessence to be the spark of the divine in

the human, of the heavenly in the earthly, of the infinite in the finite.

In this book, the problems associated with tooth wear (TW) are approached from four different aspects, elements, or basic dimensions: physical, functional, psychologic, and social, to which is added a fifth dimension, fifth element, or fifth essence, so to speak. As with alchemy, the preservation of the teeth involves a series of elements and combining these in the best way possible to achieve quintessence.

The esthetic dimension could be considered as the fifth element of those contributing to dental well-being. Just as quintessence, or ether, was the purest natural element, or essence, for the ancient philosophers, the esthetic dimension is the purest element, or essence, when facing the challenge of TW.

As the essence of the alchemists was centered around an element that offered the perfect combination of the other elements, it is important to clarify that we consider here a wider sense of the concept of esthetics, in its Greek meaning. In this way, we understand esthetics in its deepest and most profound state.

Esthetics is connected to feelings and how those feelings are perceived: the outside world, the world we see, what we hear, what we taste, what we smell, and what we touch. While esthetics can be approached according to the relationship each individual has with the world around them, it can also be approached according to the relationship each one of us has with others. Esthetics is the domain of the senses and perception. It encapsulates both the perception we have of others and the perception others have of us, and in turn the perception that we have of the perception that others have of us.

The teeth occupy a fundamental position in personal esthetics; the mouth is one of the principal and primary ways we present ourselves: a personal cover letter. Dental esthetics are a fundamental pillar for self-esteem and an individual’s confidence; therefore, through our mouth, teeth, and smile we are able to communicate a lot about ourselves, our personality, and our moods. The perception others have of us is very much related to the appearance of the mouth and teeth.

How do others perceive me? What image do I present of myself? Do I give off a youthful image, do I come across as a healthy person, confident in myself, and what in turn is of interest to others?



The response to these questions involves the teeth and the mouth as fundamental components. A person with a deteriorated mouth seems aged, in a bad state of health, and is going to feel as though others see them in this way too. Therefore, people may feel their self-esteem is undermined, and this in turn projects an even more deteriorated self-image; it is a vicious circle.

Think on this deterioration, of how it is perceived by others and how it is going to continue, affecting the different areas of the mouth in an itinerant, constant, and

progressive way. This thought will lead you to be aware of your finiteness and that the Universe, with its huge regions where the ether dwells, will continue its course without you being able to do anything to prevent it. The divine quintessence in its eternal and perfect movement is unconnected to this suffering.

Alberto Álvarez Fernández

Spanish philosopher and economist, childhood friend of the authors

Foreword

Drs Debora and Beatriz Vilaboa have a passion for dentistry that has pushed them to search for better ways to deliver treatment while respecting the benefits of tooth preservation. Their enthusiasm for and dedication to this work is transmitted to their students and their team. In this book, they now share their vision with a wider audience.

After medical and dental school, Drs Vilaboa wanted to address the need for dental restoration with a legitimate desire to improve smiles, and they pioneered with other colleagues in esthetic dentistry. They believed in restoring worn dentitions and anterior guidance with porcelain laminate veneers and worked to overcome the general reluctance toward adhesive restorations in a time when traditional prosthodontics seemed preferable.

They have always described their career as a “journey,” and I have been honored to count myself as a companion on that journey. Not only have they attended every continuing education seminar and congress that I have organized, but I was proud to mentor them as they became active members of the European Academy of Esthetic Dentistry and have remained an active part of their family since then. I had the pleasure of knowing their father and mother and brilliant brother Jorge. In addition, the parallelism between Debora’s and my family has been a matter of joy for all of us, and in both families, the next generation (Jose Manuel and Alfonso, through surgical

and restorative disciplines and Debora and Jaime as orthodontists) has also chosen to devote their lives to dentistry. The torch is being passed on.

The Vilaboa family is one of business talent. Their group practice is well structured and patient centered and a source of inspiration to us. It has flourished because they understood how a multidisciplinary approach and the fluent use of the newest digital tools could enhance the patient experience and the treatment processes.

Inside this book, readers will find an integrative and multidisciplinary approach to tooth wear, which covers surgery, implants, orthodontics, and restorations (both direct and indirect), with the goal of improving oral health and achieving esthetic dentistry. In addition, the economic burden of tooth wear is softened with well-supported protocols that help make treatment accessible in all cases.

Overall, this is a comprehensive book for tooth wear that is easy to read and that effectively compiles all clinical aspects—from the concept and diagnosis to treatment and communication. Enjoy the reading and we will continue to meet along the journey.

Professor Jaime A. Gil

President International Federation of Esthetic Dentistry (IFED)

Preface

The appetite for new restorative paths continues apace. At the same time, the digital evolution of the dental industry continues to thrive, with unprecedented possibilities for a more precise and predictable outcome.

This may well be a pivotal moment for the practice of dentistry with the advent of full digital workflows and the intermediate traditional-digital hybrid to suit all practitioners.

Whether the dental practitioner is a digital flow purist or a believer in traditional chairside dentistry, the patient always remains analog, reminding us that the mouth truly is a live test bench with the patient headlined for comfort, well-being, and a pleasing result.

As in any other field, flexible and prepared human power leads to productivity and efficiency improvement.

Sticking strictly to only one flow, be it CAD/CAM or manual, may be holding the overall process back from time-saving and precise outcomes both in the diagnostic and restorative phases.

The approach of treating only to repair diseased tissue associated with lesions may prove a limited perspective, while the trend to treat in a primarily esthetically driven way may leave the patient unprotected as a concomitant shift in lifestyle can be devastating in already demineralized tissue.

Perhaps one can be tempted by a self-content attitude, delivering restorations in the same manner as with any other dental condition. But in doing this there is not much space to ask oneself why. Why has this happened? Why has the patient lost the protection of saliva? Why are the lesions different in every patient, and even within

the same mouth? Why is there no pain? Why is there no space? Why is the patient oblivious of so much tooth structure loss? Why are we more prepared to choose our preferred treatment option? Why are we doing that? Why is it necessary? Why should the patient with TW have the same regular checkups as other patients?

In asking yourself why, you will serve the patient better, as many procedures that initially would have been deemed necessary will probably be left out after questioning whether the principles of maximum tooth preservation are still present, making the overall treatment more accessible and acceptable for the patient. Nonetheless there should be general rules or protocols as in any other field of medicine, as any decision will have an impact not only on the treatment outcome but on the overall tooth survival.

Artificial intelligence and facial and surface recognition will most probably deliver treatment tools unimaginable today.

The recognition that preventing TW and intercepting further TSL may be less hazardous than imitating nature has made a quantum leap in recent years. All disciplines of modern dentistry and medicine, when focused on early detection and minor intervention, may demonstrate a shortcut to flatten the TW curve.

When reading this book, the authors hope you have a feeling of a *déjà vu*, as this is intended to be a reader-friendly compilation of observation, study, and clinical work that surely you too have experienced. If so, we hope it inspires clinicians who wish to treat TW patients.

Embark, and enjoy your journey;



Dedicated to

Our families with love.

My son, José Manuel, whom I admire.

My daughter, Débora, who fills my life with joy.

With gratitude to both of them for following in my professional steps.

Laura, who has enriched our family.

Manuel, a source of joy and strength.

My husband, José, who always believed in me.

Diego, the sunshine of my life.

My husband, Jesus, for thinking I am the one.

Our brother George, the leader of our family; Marta, the love of his life; Clara, the new orthodontist in our family; Bea; and Paula.

In loving memory of Manuel and Pilar, our parents whose love inspired us all.

Débora and Beatriz R. Vilaboa

Manu, you are my world. My mother Débora and my aunt Beatriz, my role models.

My father, the most positive person I have ever met. My brother, the best working partner I could ever have.

The women in my family, Patricia, Marta and Eva for their generous and unconditional support. To Manuel and Jose for your love to Manu and me.

Clara, Beatriz, Paula and Diego we have grown together with an unbreakable bond.

S. Ochandiano, D. Martin, M. Pulido, B. Mateo, E. McLaren, R. Romano, De Rossa and D. de Franco, my true inspiration. Débora Reuss

Laura, my love, my everything.

My mother and father, sister, and aunt, for their endless love and support.

My mentors, Drs Martínez Corriá, Gil, and Moy. Your input in my professional life is priceless.

José M. Reuss

Thank you

This is a dedication to those who have accompanied us throughout our professional and personal lives. Thank you to our patients for blessing us with their confidence.

Thank you to our team for believing in our project. Thank you to Drs Mercedes Pulido, Borja Mateo, Amparo Llorente, and María Araujo; we have sailed many seas. Thank you to Dr Marta Lago; your father would be proud of you. Thank you to Drs Verónica Rubio, Laura Peix, Cristina Fernández, Jaime Fernández, and Beatriz de Luján for enriching our restorative mission. Thank you, Julia, Verónica, Adina, Juana, Sandra and Marisa. We need you so much. Thank you, Ángel, Karmel, and Andrea, you landed in the middle of the storm. Thank you, Carmen Fernández and Jess Ride-Out, continuing our writing during the weekends was easier with your help. Thank you Silvia Muriel, you have been an asset.

Thank you to Laura Cifuentes; we knew from the beginning we were in good hands. Thank you, Rocío Pérez Durias, you inspire us. Thank you, Paloma, for taking the torch. Thank you Marc Romea for the support and input.

Thank you to Elena Pérez, you said you would do it, and you did it. Thank you for being with us. By the way, yes, you are kidnapped and the ransom payment will be high.

Thank you to Carlos Barja, Gonzalo Medina, Santiago Dalmau, and your team. Thank you to Stefano and Fernando Tonarelli; God bless our lecture in Warsaw. Thank you to the Rutten brothers. Thank you to Javier Rubio and to Arturo Calvo.

Thank you to our family from the European Academy of Esthetic Dentistry for your friendship and support.

Thank you to Jaime Gil for your lifelong mentorship. Thank you to our colleagues from BQDC. You are the best.

Thank you to Alberto Alvarez for your reflections. Thank you to Gonzalo Rada for your drawings. Thank you to Ines Castellanos for your lifestyle photography.

Thank you to the Haase family. You are not just our editors; you are much more than that.

Débora and Beatriz R. Vilaboa,
José Manuel and Débora Reuss

**BEATRIZ R.
VILABOA**

Dr Beatriz R. Vilaboa received her degree in medicine and surgery with honours from the Complutense University of Madrid from which she also attained her specialty in stomatology. She joined Clinica Vilaboa in Madrid soon

**Authors****DEBORA R.
VILABOA**

Dr Debora R. Vilaboa graduated from the Complutense University Faculty of Medicine and Surgery in Madrid. The same year, she was accepted at the Seville School of Dentistry, where she obtained her dental

degree. Later on she chose to attend the Advanced Pediatric Dentistry Program at the University of Southern California in Los Angeles.

After establishing the Vilaboa Clinic in 1987, she found that some cases could not be explained by caries nor periodontal disease and began gathering data. She lectured on tooth wear as early as 1992, both in Spain and the United States. Understanding how to approach the treatment of young children helped Dr Deborah Vilaboa in her work with tooth wear patients, many of whom had a fear of dentistry. As a pioneer in the field of porcelain laminate veneers, she treated such cases with a novel adhesive concept.

Dr Debora Vilaboa soon became a member of the Spanish Society of Stomatological Prosthetics (SEPES) and the Spanish Society of Periodontology (SEPA). Her passion for treating patients and continuing education was rewarded in becoming an active member of the European Academy of Esthetic Dentistry (EAED). She was then able to pursue her restorative and prosthodontic interests, thanks to a truly collaborative and generous exchange of knowledge among the active members that is still a driving force for the team at Vilaboa Clinic. She is also an active member of the Italian Academy of Esthetic Dentistry (IAED).

Dr Debora Vilaboa was invited by the San Pablo CEU University to create an undergraduate Esthetic Dentistry Department that she co-directs with her sister, Dr Beatriz Vilaboa. She lectures worldwide in esthetic dentistry, with a focus on tooth wear. She was a contributor to *Esthetics in Dentistry* (Quintessence, 2016). Given her medical background, Dr Debora Vilaboa is devoted to understanding and treating conditions arising from medical and oral imbalances, and through her research, she has obtained several patents related to her work. She is an active member of the American Academy of Oral Medicine (AAOM), a fellow member of the International College of Dentists (ICD), and an academic at the Pierre Fauchard Academy.

after her sister Dr Debora R. Vilaboa founded it in 1987. She enjoys her private practice at the Vilaboa Clinic, dedicated to esthetic and restorative dentistry. Her devotion to treating patients using the most conservative approach possible motivated her to embrace the adhesive-additive concept to provide solutions to the tooth wear patient. Her interest in tooth wear culminated with a PhD from San Pablo CEU University Faculty of Medicine in Madrid, where she is now Co-Director of the undergraduate Esthetic Dentistry department. Dr Beatriz Vilaboa's passion for teaching is also evident in the many courses that she and her sister have given over the last 30 years.

Dr. Beatriz Vilaboa has the honour of being an active member of the European Academy of Esthetic Dentistry (EAED) and the Italian Academy of Esthetic Dentistry (IAED). She is also founding member of the International Academy of Adhesion (IAA). Her desire to better help patients suffering from cancer and other major medical conditions pushed her to become a member of the American Academy of Oral Medicine (AAOM). She is also a member of the Spanish Society of Stomatological Prosthetics (SEPES) and Spanish Society of Periodontology (SEPA), as well as a fellow member of the International College of Dentists (ICD) and an academic from the Pierre Fauchard Academy. She lectures worldwide on esthetic and restorative dentistry and especially on tooth wear.

Dr Beatriz Vilaboa treasures friendship with colleagues worldwide and believes that the common passion for dentistry goes beyond borders.



JOSE MANUEL REUSS

Dr Jose Manuel Reuss graduated in dentistry from the University Complutense of Madrid, where he also obtained a Master's Degree of Science. As a postgraduate in surgical implant dentistry at the University of California at Los

Angeles, he was a recipient of a grant from the American Academy of Implant Dentistry for preclinical and clinical research. During his postgraduate research, he focused on bone regeneration with growth factor technologies.

Dr Jose Manual Reuss's clinical background both in implant surgery and prosthodontics has led him to develop a facially guided restoration concept. In particular, severe tooth wear or highly dysfunctional cases can benefit from the combination of digital protocols and a more traditional classical workflow. His current clinical and research foci lie on the integration of facial scanners into guided surgery systems, restorative protocols, and clinician-technician communication.

As an affiliate member of the European Academy of Esthetics Dentistry, he is an enthusiast of multidisciplinary thinking and is therefore also a member of the Spanish Society of Prosthodontics (SEPES), the Spanish Society of Periodontics (SEPA), the Academy of Osseointegration (AO), and the European Academy of Osseointegration (EAO).

Dr Jose Manuel Reuss is a Collaborating Professor in the Postgraduate Prosthodontics Department in the field of implant and restorative dentistry at the University Complutense of Madrid, the University of Leon, and at the Esthetic Dentistry Department at the University San Pablo CEU of Madrid. His current focus of research is digital implant dentistry and severe tooth wear with the aim to optimize diagnostic and treatment phases and engage the working team in research. His goal to simplify the communication between the team members of an integrated multifaceted treatment plan challenges Dr Reuss almost as much as his passion for sports in his personal life.



DEBORA REUSS

Dr Debora Reuss obtained her Master's Degree in Orthodontics at the European University of Madrid, 4 years after graduating as a dentist from San Pablo CEU University of Madrid. Having completed several postgraduate specialty courses (including Damon self-ligating and Invisalign systems), she joined the Spanish Orthodontics Society (SEDO) and the Spanish Society of Aligners (SEDA). As a Member of the American Association of Orthodontics (AAO), she is a firm believer in facial- and profile-guided orthodontics.

Dr Reuss trained in occlusion at the Pankey Institute of Miami and believes that a classical concept of occlusion must be a driving force in treating orthodontic patients. Her passion for treating patients within a multidisciplinary approach has inspired her to attend continuing education courses on occlusion, restorative, and prosthodontic topics and is the reason behind her affiliation with the Spanish Society of Stomatological Prosthetics (SEPES) as well as the reason why she became affiliate member of the European Academy of Esthetic Dentistry (EAED) and the Italian Academy of Esthetic Dentistry (IAED). Dr Reuss teaches at the Esthetic Dentistry Department at San Pablo CEU University of Madrid.

Multidisciplinary thinking led her to join the Vilaboa Team in Madrid to help treat tooth wear patients with a minimally invasive philosophy to prevent further wear and to ensure conservative performance of the required restorations. An education in three-dimensional thinking as an orthodontist is key in leading the tooth wear team to a facially guided restoration as an architect of the oral complex.



“

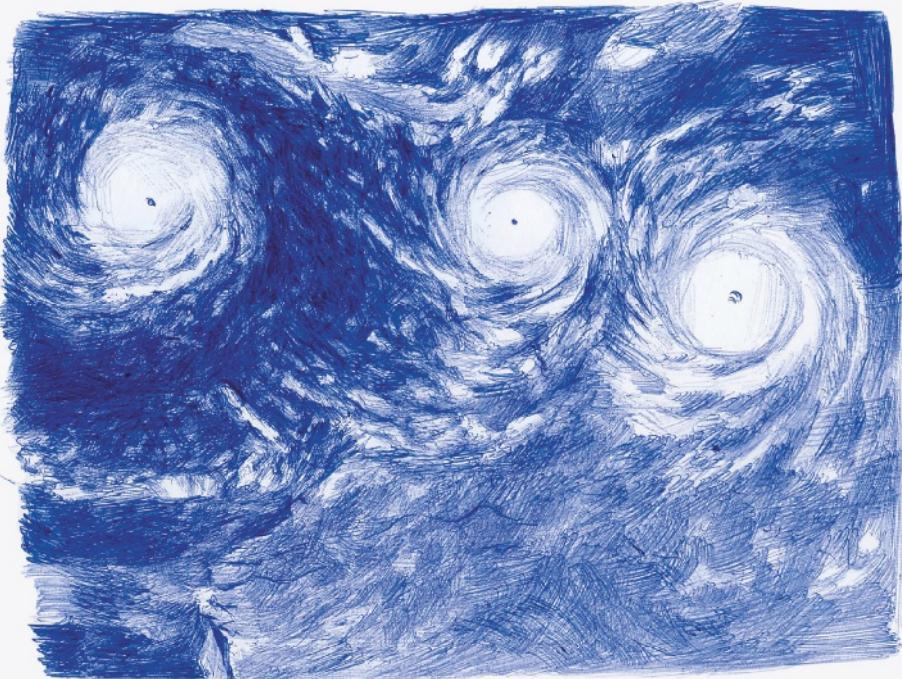
Teeth talk; you just need to watch.

SECTION I

UNDERSTANDING

TOOTH WEAR





“

The Perfect Storm: A critical or disastrous situation created by a powerful concurrence of factors.

—definition from the Merriam-Webster dictionary



CHAPTER 1

TOOTH WEAR: A MAJOR HEALTH ISSUE

Tooth wear (TW) understood as non-carious surface loss is damage to teeth—Independent of trauma or bacteria and not explainable by the patient's age—that can compromise tooth survival.

TW may well be one of the biggest challenges posed to both the dental professional and the patient today.

Progressive, irreversible, multifactorial, and insidious in nature, it ideally requires a comprehensive approach and a trained team with the ability to recognize TW at its earliest onset and establish preventive measures and a patient-centered treatment path.

Conversely, a wait-and-see attitude is not desirable as wear progression may prove devastating even in young dentitions over a short period of time. The course and cycle of TW is closely interrelated with general health conditions and lifestyle, with a documented negative impact in four dimensions: physically, functionally, psychologically, and socially.

Yet there is a fifth dimension when facing the challenge of TW connected to feelings, well-being, self-esteem, and self-image.

Understanding TW, finding better treatments for our patients, and contributing to a flattening of the TW curve is a team task.

1. The Global Burden of Tooth Wear

Over the last decades, TW has trespassed beyond the boundaries of anthropology, gradually invading the pages of peer-reviewed journals, congresses and webinars of the restorative and prosthodontics fields of dentistry.

Traditionally, the wearing of the dentition has been considered a consequence of aging. Even though TW can occur at any stage of life, it is in adulthood and beyond where TW is most prevalent. The world is seeing an unprecedented growth in its aging population throughout all countries and regions, an effect of globalization. It is only a matter of time before this growing group of patients with worn dentitions will include everyone of us, if it has not already. While longevity is a success story, not preparing protocols and services according to growing needs will negatively impact our practices in the long run and may exclude wide sectors of our society from the benefits of the aftermath of development and well-being.



Fig 1-1 This image shows that worn enamel caused by grinding or tooth clenching can facilitate further tooth loss with the onset of acidic attack. This 62-year-old male patient was diagnosed with GERD at the age of 60. The acidic attack onset will meet with an already worn, flattened tooth that lacks enamel protection and is therefore more susceptible to erosion.

Life expectancy has also been stated to be responsible for the deterioration of the dentition, as well as other aspects of the oral cavity such as salivary function. Other parameters like general health and lifestyle of the individual are key to oral health and a well-maintained tooth structure. Today oral health is regarded as an integral part of general health, especially after multiple studies have linked oral health to major health conditions (Fig 1-1).

TW is undoubtedly a challenge for the dental profession in the current decade.

Commonly undiagnosed and unfortunately underestimated during the initial stages, TW, when left untreated, leads to anatomical loss of valuable tooth structure, increased permeability of pathogens, functional

impairment, psychologic impact, social disability, and esthetic changes. Pain, high risk of tooth fracture, and eventually premature tooth loss will follow long-term untreated severe TW.

TW is also responsible for facial and dentoalveolar compensation that is unfortunately unable to overcome the bone consequences of premature tooth loss.

TW is common in patients throughout the world, in some cases associated with habits like acidic diets. Strikingly, young adults and even children may experience TW to a noticeable amount by the time they are diagnosed. It is often asymptomatic for many years until an issue such as a fracture, restoration failure, or abscess brings the patient to the office (Fig 1-2).

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Fig 1-2 The radiographic exam of this young adult revealed both low incidence of caries and periodontal compromise (a). Single tooth-oriented treatments have not been able to prevent TW from progressing. Hard tissue loss is seen in the form of disappearance of occlusal and facial anatomy and topography of cusps and occlusal fossae. Note the remaining composite restorations resisting erosive attack. Photos were taken before any hygiene and prophylaxis was performed, and the low presence of biofilm is noticeable (b to d). (See more on this case in chapter 7.)

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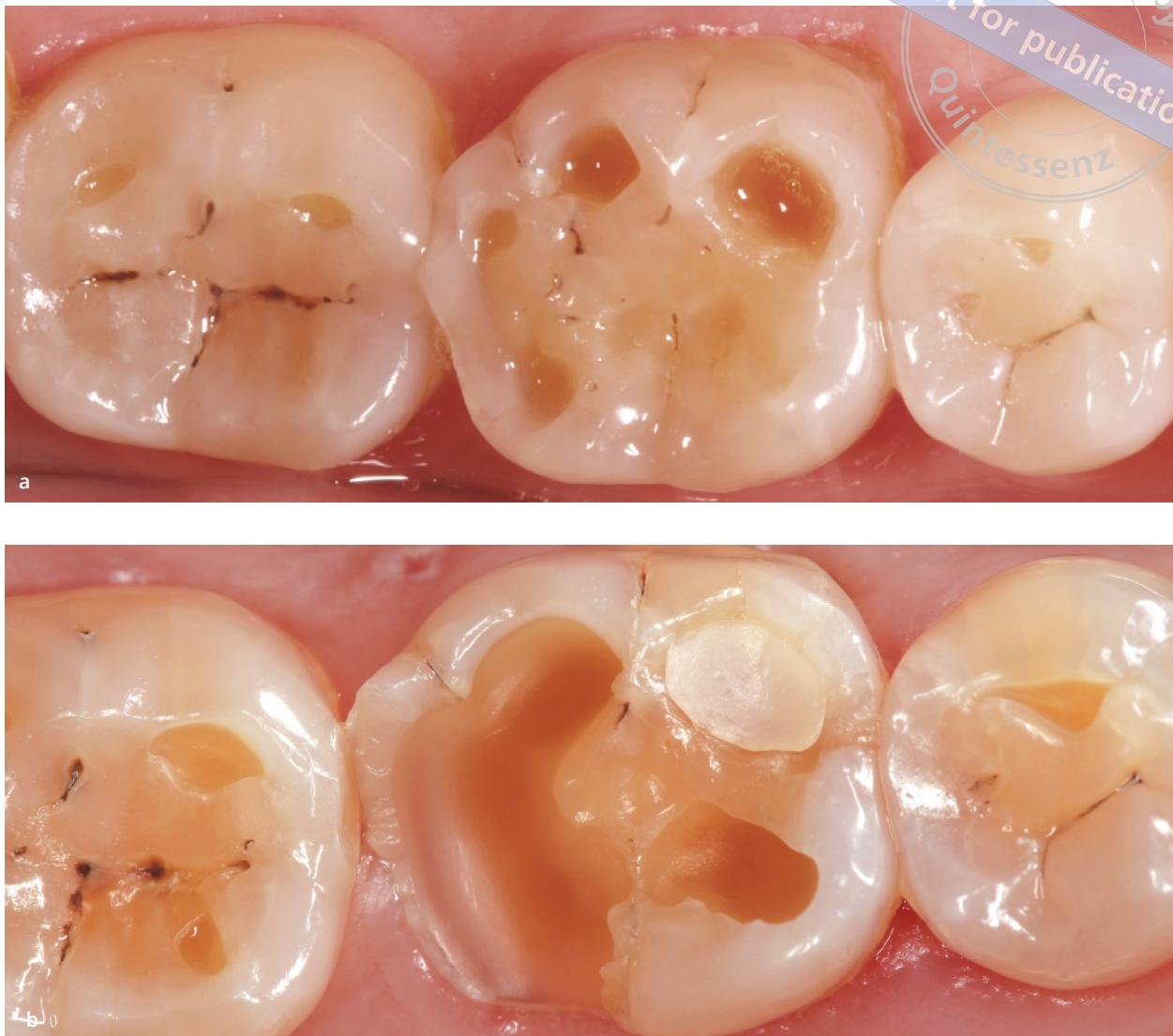


Fig 1-3 A 55-year-old male patient with exposed dentin as a result of prolonged exposure to an acidic environment. Patient was free of symptoms despite the obvious erosive lesions (a). Progression of tooth structure loss of untreated lesions over an 8-year time period (b).

The wait-and-see approach can have unprecedented consequences as TW is multifactorial, cyclic, and progressive. Even in the absence of the original etiologic factor, it can lead to further tooth loss in the original site of TW or distant sites of the mouth (Fig 1-3).

In the 2020s, TW is defined by irreversible tooth surface loss (TSL) affecting either enamel or enamel and dentin by factors different to the ones responsible for caries or trauma.¹ This loss of tooth structure comprises damage to the macro and micro aspects of teeth. The different clinical presentations include attrition, abrasion, abfraction, and erosion, or a combination of all of these.

The increasing number of papers on TW and erosion serve as evidence of the exponential growth of awareness of dental practitioners and researchers regarding this topic. This comes as no surprise since both the occurrence and severity of TW has been growing rapidly over recent decades.

Furthermore, escalating occurrence in the young population today predicts an avalanche of worn dentitions, dramatically changing the scenario to one in which dentists will have to perform and deliver restorations susceptible to more failure² (Fig 1-4).

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Fig 1-4 Multifactorial TW in a 38-year-old male patient. Note distinctive vestibular defects in relation to a combination of abrasion, erosion, and abfraction, together with generalized manifest erosive damage (a). Capricious occlusal anatomy evocative of an erosive skyline landscape (b). Roller coaster incisal profile (c).



Fig 1-5 Note in the panoramic radiograph periapical lesions in relation with extreme TW (a). A 68-year-old male patient with multifactorial TW lesions such as attrition, abrasion, abfraction, and erosion (b). Most of the enamel and dentin is gone, exposing pulp chambers and root canal filling materials with severe TW and premature tooth loss (c).

Moreover, the geriatric challenge for dental medicine associated with a still-lengthening life expectancy comes from the fact that preventive strategies in the adult, plus better hygiene and nutrition, as well as preventive and treatment strategies of comorbidities of dental diseases (eg, caries and diabetes, periodontitis and cardiovascular conditions), have provided the opportunity for more people to keep their teeth even in the later decades of their life.

Some authors have anticipated that edentulism will be present in only 2.6% of people by 2050, mostly in the oldest and poorest demographic groups³ (Fig 1-5).

On the other hand, the emerging number of people diagnosed and treated for cancer, and very recently those with secondary effects of the COVID-19 virus, pose a challenge as erosion will be present in dentitions even in the absence of high acidic affluence. Polypharmacy, chemotherapy, and noncommunicable general health conditions will course with salivary gland dysfunction, be it hyposalivation or alteration of the composition of saliva, a hidden cause and potentiator of TW, as will be discussed in chapter 2.

Dental professionals will have to do a quantum leap in their understanding of TW and have a cascade of



Fig 1-6 Erosive wear in a 27-year-old woman with noticeable absence of bacterial plaque and distinctive perimolysis pattern with exposed dentin and intact enamel at the gingival margin. Generalized loss of palatal anatomy leads to breakage of incisal edges and crown shortening. (See more on this case in chapter 7.)

possible treatment strategies to be able to care for their patients in this prospective future (Fig 1-6).

While caries and periodontal diseases are plaque-related conditions, TW is independent of the level of plaque accumulation. In fact, caries and erosion cannot happen simultaneously on the same tooth surface at the same time.⁴

While innate defense mechanisms against caries are multiple and effective in healthy patients to contain progression of or even revert the lesion, erosion and attrition—and the combination of both—are progressive and do not encounter a remineralizing parallelism.

Plaque-removing strategies and fluoride together with hygiene measures can change the course of carious disease. Unfortunately, such preventive measures do not stop TW.⁵

Caries is a classic condition that is easily recognized and managed by dentists and their teams when compared to TW. The decline in caries incidence and rate of

progression in some countries has shifted caries intervention toward a less invasive approach.

However, the type of restorative approach is far more dependent on the professional ability and background of the dentist than on the disease of the patient. In fact, both the treatment strategies and the diagnosis vary widely between dentists who do not make an individual diagnosis and evaluation but rather respond automatically towards caries.⁶

Many factors have been accounted for in the variability of treatment decisions between dentists when confronting caries. These include dentist education, oral hygiene status, financial considerations, workload, number of years in practice, school attended, and the dentist's feeling on the speed of progression of the lesion, all of them leading to false-positive and false-negative interventions.⁷

The decisions on why, how, and when to intervene on a tooth are going to affect its life cycle and survival as well as the oral status of the patient.



Fig 1-7 Note incisal edge wear in a 62-year-old man associated with a long-standing malocclusion in an otherwise healthy and functioning mouth. (See more on this case in chapter 8.)



Fig 1-9 Erosive damage in a young female patient. Incisal wear due to palatal erosion. Note translucency due to palatal structure loss. (See more on this case in chapter 7.)



Fig 1-8 Teenager with incipient TW affecting incisor edges and canine cusps due to a parafunctional habit (lip biting). (See more on this case in chapter 5.)



Fig 1-10 Acid erosion dissolution of tooth structure in a young woman. Note the characteristic remaining enamel halo at the gingival margin.

2. Physiologic Versus Pathologic Wear

Experts agree upon the fact that a certain degree of TW is physiologic with the passing of the time. However, excessive or premature wear cannot be related to age. In other words, premature TW that occurs in the younger patient cannot be attributed to the patient's age.

Notwithstanding the above, the acceptance of a normal amount of TW should be taken into consideration relative to the patient's age. For example, incisal edge wear in the absence of other findings like insufficient guidance protection in a 62-year-old patient is reasonably compatible with good oral health and may only need consideration from an esthetic point of view (Fig 1-7).

Conversely, in a teenager, incisal or canine cusp wear should raise concerns as parafunctional habits may lead to exponential damage in future years. The insidious character of TW causes a subtle change in the anatomy that goes unnoticed to the untrained eye (Fig 1-8).

Despite the existing debate around the definitions and terminology in the universe of TW, there seems to be agreement that while attrition or abrasion to a certain extent can be physiologic, erosive damage should

always be considered to be pathologic (Figs 1-9 and 1-10).

3. Anthropologic and Contemporary Tooth Wear

The story of human evolution, where we come from and who we are, has been explained through morphologic study and more recently with the aid of the genome of fragmented human fossils. The anthropologic study of the human dentition, more than any other part of the body, has contributed to our knowledge about our primitive ancestors.

Attrition and abrasion have existed since the beginning of humanity. Teeth were utilized as tools to soften, blend, and tear raw materials like animal skins, branches, and hunting devices.

Interestingly, in specimens from our ancestors dating back to the early medieval ages, erosion seems almost nonexistent (Figs 1-11 and 1-12). Similarly, anthropologists are not familiar with the emerging phenomenon of erosion, as no signs of erosion are seen in prehistorical fossils.



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Fig 1-11 Attrition and abrasion signs in this specimen from the Middle Ages before the advent of the modern “erosive era.” (Courtesy of the Anthropological Collection of the Museum of the School of Legal Medicine at Complutense University of Madrid.)



Fig 1-12 Note the caries- and erosion-free dentition despite the primitive oral hygiene regimen in the Middle Ages. The absence of fast food or cariogenic drinks and the presence of a local, non-industrialized diet explain the lack of caries and erosion signs. Harsh and coarse food ingredients such as in hunted meat and/or raw vegetables and grasses support the attrition signs. (Courtesy of the Anthropological Collection of the Museum of the School of Legal Medicine at the Complutense University of Madrid.)



Fig 1-13 The accuracy that photography and new technologies provide today, together with the increasing understanding of TW, enables a better differentiation of the mechanisms behind TW. However, the concomitant and alternant course of the different origins of TW pose challenges, both to the patient and the dental team, in the everyday practice.

Biologic anthropology considers that human functional evolutionary adaptation starts in climate and environmental changes that in turn dictate the form, size, and characteristics of humans.

The concept “form follows function,” originally coined for industrial design, can be applied to the adaptation of teeth throughout human evolution. When humans of the *Homo* genus started to eat fruits and meat and later were able to cook with the discovery of fire, teeth proved unnecessarily wide and large and consequently started to evolve to a smaller size.

The canine of hominids diverged in form from the ape's, losing prominence in the arch. By the time the humans of the *Homo* genus settled down, their canines were essentially like ours today, drawing a slightly curved line in harmony with the row formed by the incisors.

The increased thickness of the human enamel appears to be an adaptation to a longer life expectancy of humans, who benefit from a reservoir of wear-resistant, non-shedding tissue for the years to come.⁸

Rapidly occurring extensive wear in the short life span of prehistoric humans of the *Australopithecus* genus found in specimens of South African fossils are a manifestation of very abrasive diets in otherwise caries-free and erosion-free individuals, as acid erosion is an unseen phenomenon until modern times.⁹ For many decades,

anthropologists did not distinguish between the three major terms *abrasion*, *attrition*, and *erosion*, even though erosion was almost absent in anthropologic libraries borrowing the term from geologists.

It is only recently that dentistry has differentiated clearly between these three mechanisms that affect modern dentition. Nevertheless, complexity lies ahead as they can be overlapping, subsequent, or concomitant¹⁰ (Fig 1-13).

4. Prevalence of Tooth Wear

Several difficulties lay behind the ample variation of results when assessing TW prevalence. First was the lack of a universally accepted case definition. Second was the difficulty in accepting a unified TW index. When using the TW term and its different subcategories, some authors refer to TW as a synonym to erosion, whereas others clearly separate erosion and TW into different categories.

Lifestyle and contemporary habits have created the actual TSL scenario (Fig 1-14).

Double-digit figures of the prevalence of TW, ranging from 70% in primary dentition in German children¹¹⁻¹³ to 78% in the same age group of Australian children,¹⁴ reveal a reason to worry.



Fig 1-14 Lifestyle and dietary habits with acidic fruits and beverages are behind many cases of TW in young patients today.



Fig 1-15 Incipient TW in an adolescent clinically diagnosed during a checkup for hygiene and prophylaxis with a hygienist (a). Detail of flattening from incipient TW lesions affecting incisal edges as well as canine cusps (b).

Prevalence of TW in permanent dentition ranges from 8% to 31% in 14-year-old children in the United Kingdom, while other teenager populations show an overall prevalence of 10% to 90%^{15,16} (Fig 1-15).

Although epidemiologic studies have predominantly studied children and the younger population, research has shown a high incidence of TW in adults that may affect up to 77% of their anterior teeth.¹⁷ Sex distribution

has shown a significantly higher occurrence of TW in males with ratios such as 2.3:1¹⁸ and 1.7:1.¹⁹

Lifestyle, dietary habits, and stress, together with higher masticatory forces, may explain the higher occurrence in men. Severity of wear has also been found to be higher in men than in women.²⁰

An exception is TW found predominantly in women suffering from eating disorders.



a



b

Fig 1-16 Erosive wear with enamel dissolution in a male patient in his 60s with chronic unspecific digestive complaints compatible with the presence of gastric reflux and an active social life (a and b).

5. Tooth Wear and General Health

The modern concept of general health is inseparable from oral health. TW when left untreated evolves into an oral condition that impacts negatively on quality of life. TW is commonly present in cases of premature tooth loss.

Failure to detect moderate to severe cases of TW and treat them with restorative, noninvasive approaches, leaves the patient and the dentist victims of repeated tooth-oriented treatments that unfortunately will not change the evolution of TW.

In order to understand comorbidity of TW, it should be taken into consideration that the oral cavity is part of both the digestive and respiratory tracts (Fig 1-16). Therefore, any condition that affects the respiratory apparatus may cause damage in the oral cavity and vice versa. Pneumonia, pulmonary fibrosis, and asthma can be triggered or caused by poor oral hygiene, a shift in the oral microbiome, or a definite oral dysbiosis. This has been acknowledged recently as the *oral-lung axis*.²⁰

Conversely, patients with mouth breathing, obstructive sleep apnea (OSA), pulmonary insufficiency, chronic obstructive pulmonary disease, or pulmonary fibrosis and patients on an oxygen regimen exhibit varying grades of TW.

Similarly, patients with gastroesophageal reflux disease (GERD) have a higher incidence of dental erosion with a reciprocal negative effect. It has been found that patients with GERD have a low salivary flow.²¹ In another study by Correa et al, while there was no significant

difference between patients with GERD and a control group when it came to salivary flow, the results showed a significant difference in the salivary buffering capacity, with it being lower in the GERD group²² (Fig 1-17).

On the other hand, patients with worn dentitions and impaired mastication are at higher risk of esophageal and gastric disease, which can be the origin of the TW, and in a vicious cycle the worn dentition can aggravate and perpetuate the digestive problems (Fig 1-18).

Saliva is the most important biologic factor affecting the progression of dental erosion.²³ Medication-induced salivary gland dysfunction (MISGD), specifically a decreased salivary flow or a change in the salivary composition, is a common comorbidity of many conditions and diseases and their associated medication. In the 2014 World Workshop on Oral Medicine, clear conclusions arose identifying the strong connection between medication and xerostomia, with xerostomia occurring in almost 50% of patients taking antihypertensives. This percentage increased to 71% in patients taking antidepressants.²⁴ Intake of prescribed medications follows a growing pattern as stated by the data collected by health organizations such as the Center for Disease Control in the United States.

Another growing group of patients in whom premature, devastating TW can be seen is in those suffering from eating disorders. The prevalence of bulimia nervosa in young women reaches 5%, while anorexia, with an onset during early adolescence, has a prevalence of 2%.^{25,26}

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Fig 1-17 A 21-year-old male patient with generalized TW that has eliminated anatomical and morphologic features. The “cleansing effect” of acids removes all biofilm and impedes the adhesion of the acquired pellicle with the result of an immaculate mouth that should not hinder the diagnosis of premature wear. A presumptive silent reflux diagnosis needs to be confirmed in this very young adult.



Fig 1-18 A 40-year-old male patient with severe wear nearing pulp exposure.

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Fig 1-19 Tooth wear as the quintessential challenge. As explained in the front pages of this book, treating the worn dentition is the quintessential challenge to the dentist as the patient's functional, biologic, psychologic, social, and esthetic disability calls for immediate action.

6. The Quintessential Challenge of Tooth Wear

TW has implications for the patient in all aspects physical, functional, psychologic, social, and esthetic.

The TW treatment team should shift from restorative thinking to tooth structure thinking and spare no occasion to educate the patient in line with structure-preserving strategies. The challenge is larger today as more people remain active for longer periods of life, and the evidence is strong showing that TW, as a threat to oral health, will impact all aspects of well-being—physical, psychologic, and social—throughout a lifetime^{27,28} (Fig 1-19).

All attempts to safe and effectively improve hyposalivation will provide better chances for our TW patients.

Another aspect that should not be overlooked is the significant expense that repetitions of restorations incur for a patient. Controlling the overall cost of the patient's

present treatment and most importantly considering right from the start the expenditure that will be needed in the future should be part of the treatment strategy.

3D technologies were first marketed as a promise to render high-end restorations to more people at reasonable cost. Unfortunately, the trend is to make things more expensive and not more affordable.

The challenge remains in the hands and mind of the dentist, who needs to apply practical and accessible protocols in order to serve the goal of saving resources for the patient and to bring the treatment closer to the patient.

TW affects all spatial dimensions and planes of the dentition. 3D tools and 3D workflow when used in a patient-centered modus operandi may be of great help, even if it requires a jump from digital to analog domains to serve patients better. This aspect, described in this book as "hop-on, hop-off" from digital to analog and vice versa is further explained in chapter 4.

7. The Economy of Tooth Wear: The TW Curve Shape

The social science of economics explains through graphs and curves not only principles but also trends.

The COVID-19 sanitary crisis has increased the interest and the knowledge of the general population in terms of understanding how the economy will recover from the COVID-19 impact. Digitalization together with education and a sustainable economy are three of the recommended measures to recover and stabilize a system.

In the same manner as economists represent the market's health drop in a crisis by a downward chart, TW and its impact in oral health can follow a downhill course, implying a progressive decrease in oral and general health. How and when we intervene as a TW treatment team, depending on the treatment type and timing, will mark the recovery pattern and the future resilience to relapse.

As in economics, digitalization, sustainable treatments, and patient education in healthy lifestyle choices are key to managing TW in a dental practice, as there is no

single factor that can reduce the challenge of TW both to the dentist and to the patient.

Eventually there will be recessions, some exogenous and some intrinsic, both in economics and in health that cannot be avoided nor prevented.

In times of repeatable relapses or recessions, easy-to-implement noninvasive interventions have proven effective for dealing with TW in a clinical environment.

V-Shape Recovery

This is the ideal recovery shape and the most optimistic one. The V-shape recovery curve implies a fast and effective recovery (Fig 1-20).

Once the treatment and preventive measures have been applied, no lasting TW sequelae will impact negatively on the health of the patient.

Chances to achieve V-shape recovery are higher in cases where TW is detected, intercepted, and treated in its incipient/moderate stages. Implementing preventive measures is key to long-term recovery (Fig 1-21).



Fig 1-20 V-shape recovery.



Fig 1-21 Early treatment enables interception of TW damage provided the patient receives correct coaching regarding lifestyle habits (lip biting in this particular case). For the patient to remain free of further damage, patient-dentist communication is indispensable (a and b). (See more on this case in chapter 5).

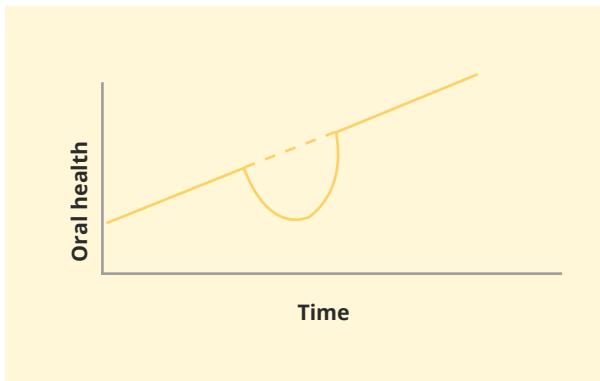


Fig 1-22 U-shape recovery.



a



b

Fig 1-23 Severe TW has destroyed all the occlusal anatomy and enamel barrier on this patient with a hopeless tooth due to extensive TW. Patient commitment is mandatory to recover and maintain the restored health (a and b). (See more on this case in chapter 9.)

U-Shape Recovery

Patients who draw a U-shape curve in their recovery pattern sustain lower oral health for a variable period of time (Fig 1-22).

This is normally the case in severe cases that require sustained patient commitment as well as a coordinated multidisciplinary treatment approach. Patients can lose their motivation as they lose sight of “the light at the end of the tunnel.” A U-shape recovery is sometimes unavoidable such as with implant or orthodontic therapy, which take time and have a complex provisionalization period and compromised occlusal support in the worst scenarios. It should be anticipated that patients can also lose their confidence in the professional team taking care of them. Furthermore, a concomitant challenge may appear (such as a new medical condition) that impedes a total recovery (Fig 1-23).

W-Shape Recovery

The W-shape curve has also been described in economy as a “double dip” (Fig 1-24).

This is the case where the patient has an initial good and effective recovery but before regaining health, relapses into another downturn or even drops out of treatment, which might endanger a good and prompt outcome. In these cases, a reevaluation should be done, and a new treatment should be discussed (Fig 1-25).

K-Shape Recovery

This happens when part of the team performs well but in an isolated manner. Despite the fact that part of the treatment plan can be a success for a certain amount of time, the overall success is challenged as there is no true multidisciplinary approach (Fig 1-26).

In such cases, the generalized TW will progress and endanger the apparently successful part of the treatment, bringing back the patient to the original status (Fig 1-27).

**Fig 1-24** W-shape recovery.**Fig 1-26** K-shape recovery.

Fig 1-25 Tobacco-related complications arose in the surgical phase, with the onset of a new surgical procedure and a demotivation process that represented a risk for the final outcome. Empathizing with the patient while reemphasizing the general treatment goal is usually helpful to regain patient's trust (a and b).

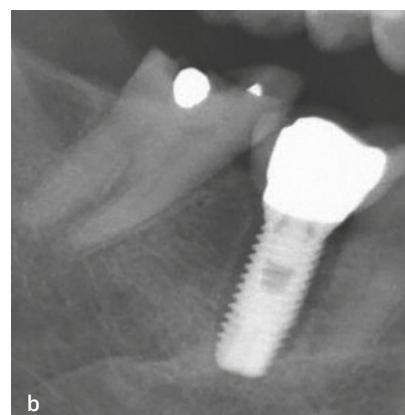
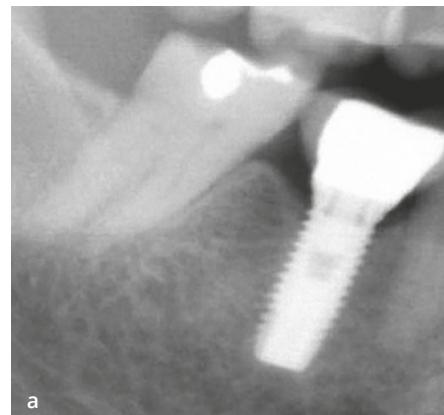


Fig 1-27 Even though excellent osseointegration was achieved, the underestimation of the overall TSL led to occlusal implant overload and implant failure. See the loss of tooth structure in the interval between the radiographs. Erosion eliminated the occlusal support of adjacent and contralateral teeth. The occlusal porcelain of the screw-retained implant crown had suffered from occlusal prematurities with repeated chipping and screw dislodgment, signs that had alerted the dentist to the issue. In this case the patient rejected any TW restorative treatment, resulting in progression to implant loss (a and b). (See more on this case in chapter 9.)

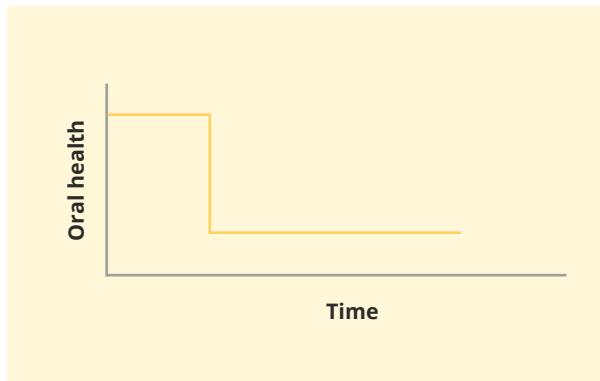


Fig 1-28 L- shape recovery.



Fig 1-29 Buccal restorations of anterior teeth performed decades ago were not able to free the patient from the TW cycle that continued to challenge tooth structure. Facially driven 3D-planned orthodontic treatment will in many cases provide the required space to allocate palatal restorations with no further tooth reduction.

L-Shape Recovery

This is the least desirable scenario (Fig 1-28).

Patient lacks motivation to undergo the treatment and to further follow preventive measures, or the dental team lacks the required experience to effectively treat the TW condition that is negatively impacting the patient's oral and general health. This also occurs when patients are treated "one tooth at a time" without a general concept and protocol and a comprehensive diagnosis and treatment plan to address TW.

Years ago, when TW was far from being understood, it was not unusual to find patients that had been treated exclusively on the labial aspect of the anterior teeth, taking only the esthetic appearance into consideration. An example would be patients seriously affected by medical conditions producing acid erosion (eg, eating disorders, GERD) with extensive dissolution of the palatal aspect of maxillary teeth that were only treated with direct or indirect labial restorations of the maxillary anterior teeth. Even though those patients were satisfied with the treatment, the TW damage continued to advance with devastating effects over the years (Fig 1-29).

8. The Geography of Tooth Wear

Tooth wear is found today throughout the world and linked mainly to lifestyle and contemporary dietary habits. Globalization is like a tsunami, diluting traditional idiosyncratic culinary patterns and leaving teeth buffeted by a merciless acidic challenge.

A review coming from Freiburg University in 2017 shows a large variation in global prevalence of erosion ranging from 0% to 100%. The lack of homogeneous study design and the fact that data are only available from certain countries, with close to zero information from the continents of Africa, South America, Asia, and many countries from southeastern Europe, explain this huge variation. As per the aforementioned review, estimating the global prevalence is complex as comparison between local studies is a complicated task due to the variation of study designs²⁹ (Table 1-1).

This review points out differences in data between the primary and permanent dentition.²⁹ For the ease of the reading, data of erosive TW both in children and adults have been summarized in Table 1-2.

The effects of characteristic, proprietary habits in certain cultures such as drinking vinegar beverages along with the use of komesu (fermented rice vinegar) and kurosu (unpolished rice vinegar) in Japan have turned out to be mild in comparison to the worldwide expansion of branded carbonated soft drinks that are cited as predominant risk factors in most of the epidemiologic studies regarding erosion prevalence and etiology.³⁰ The use of fermented and acidic food and drink in diets seems to be increasing, with the potential to change the oral microbiome in the same manner as a cariogenic diet changes the oral microbiota to acid-resistant and acid-generating bacteria such as *Streptococcus mutans*. The shift of the microbiota to a population of acidic bacteria that are adapted to an acidic environment and are themselves a source of acetic metabolites may have unprecedented consequences.³¹

Table 1-1 Global mean erosion prevalence as per the review by Schlueter and Luka.²⁹

Global mean erosion prevalence	1%-100%
Global mean erosion prevalence in primary teeth	30%-50%
Global mean erosion prevalence in permanent teeth	20%-45%

Globalized communications that favor rapid transmission of lifestyle attitudes and dietary habits lay behind the increase in erosion prevalence documented over the last decades in many countries throughout the world.

In countries like Japan, even though not many epidemiologic studies have analyzed the effect of the traditional Japanese dietary pattern versus more international foods, interesting data show how adherence to a traditional Japanese diet was associated with a decrease in diastolic and systolic blood pressure both in men and women.

The positive effect of the traditional Japanese diet should be further studied, but results so far show a beneficial link with protection from noncommunicable diseases such as cardiovascular disease and hypertension.³²

Several studies from Japan show 25% of adults presenting erosive wear. Dietary habits were mainly behind this double-digit figure. Acidic juices are to be blamed in young patients, while acidic fruits are the culprit in older patients.³³

Age-specific dietary habits were found among adults in Tokyo suffering from erosive wear. Greater soda and sports drink consumption was linked to increased incidence of erosive wear in adults independently of their age.³⁴

Accordingly, age, acidic beverages, xerostomia, and brushing habits have been shown to be behind the erosive wear found in Beijing adults.^{35,36}

Moving from Asia to North America, prevalence of erosive wear in Mexico was 31.7% in a study in which high intake of carbonated drinks and xerostomia were found to be determinantal risk factors. Mexican children consume 27.8% of their energy from caloric beverages, whole

Table 1-2 Prevalence of erosion in children and adults in various countries.

	CHILDREN	ADULTS
Australia	0%-33%	
Brazil	1%-62%	
China	6%-15%	44%
Denmark		2%
Finland		18%-75%
France		26%
Germany	32%-71%	24%-40%
Great Britain	28%-50%	3%-100%
India	29%	
Israel		37%-62%
Italy		21%
Japan		26%
Norway		20%-38%
Saudi Arabia	31%	28%
Switzerland	100%	8%-82%
USA		25%

milk, fruit juice with sugar, and carbonated and noncarbonated sugared beverages. In addition to the increasing erosion figures, a great concern regarding obesity is arising in Mexico.³⁷

Regarding Russia, there is a huge deviation in erosion prevalence among the population in different regions of Russia. In most regions the prevalence is low (from 1% to 6%); however, in some regions it can reach up to 50%.³⁸

Erosion prevalence of 17.4% found in Cuban children in a study performed in the year 2000 was linked to consumption of oranges. The specific political circumstances in Cuba at the time of the study, with Cuba isolated from the rest of the world, may explain why erosion in children was not due to carbonated soda drinks but to citrus fruits instead.³⁹

An erosion prevalence map unites data from the aforementioned research and review studies^{29,38,39} (Fig 1-30).

The role of hyposalivation in TW will be described in chapter 2. Nevertheless, its significance is so high when confronting TW that a map of xerostomia prevalence, as per a systematic review from 2018, is shown in this chapter⁴⁰ (Fig 1-31).

	EROSION PREVALENCE		EROSION PREVALENCE
Australia	0%-33%	Italy	21%
Brazil	1%-62%	Japan	26%
China	6%-89%	Malaysia	68%
Colombia	53%	Mexico	17%-32%
Cuba	17.4%	Norway	59%
Denmark	2%-14%	Poland	42%
Finland	18%-75%	Russia	1%-50%
France	26%-57%	Saudi Arabia	28%-31%
Germany	14%-72%	Spain	26%
Great Britain	3%-100%	Sweden	16%
Greece	52%-79%	Switzerland	8%-28%
Iceland	0%-31%	Switzerland	100%
India	9%-29%	Turkey	28%-53%
Ireland	47%	Uruguay	53%
Israel	37-62%	USA	25%

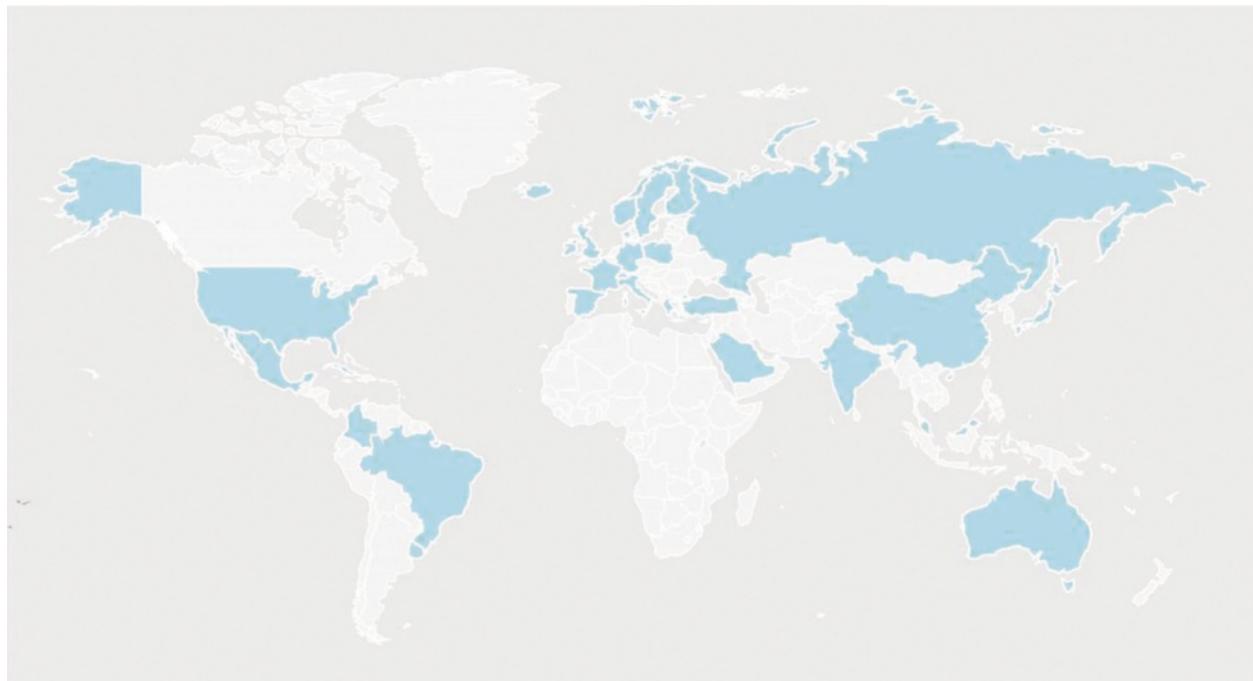


Fig 1-30 World tooth erosion map, modified from Schlueter and Lucca.²⁹ Marked in blue are geographic areas with significant documented data from erosion prevalence in children and adults.

	XEROSTOMIA PREVALENCE		XEROSTOMIA PREVALENCE
Australia	10.0%	Japan	17.6% / 10.2%
Australia	20.5%	Japan	34.8%
Brazil	11.0%	Korea	25.8%
Canada	29.5%	Mexico	45.1%
Denmark	29%	New Zealand	13.1%
England	17.2% / 15%	Norway	29.6%
Finland	11.7% / 46.7%	Spain	13%
Finland	30.8% / 40.3% / 15.9%	Sweden	27.7%
Finland	46%	Sweden	35%
Germany	0.1%	Sweden	37.4% / 57.5% / 62.3%
Israel	37.7%	USA	35.3%
Japan	16.2%	USA	39%

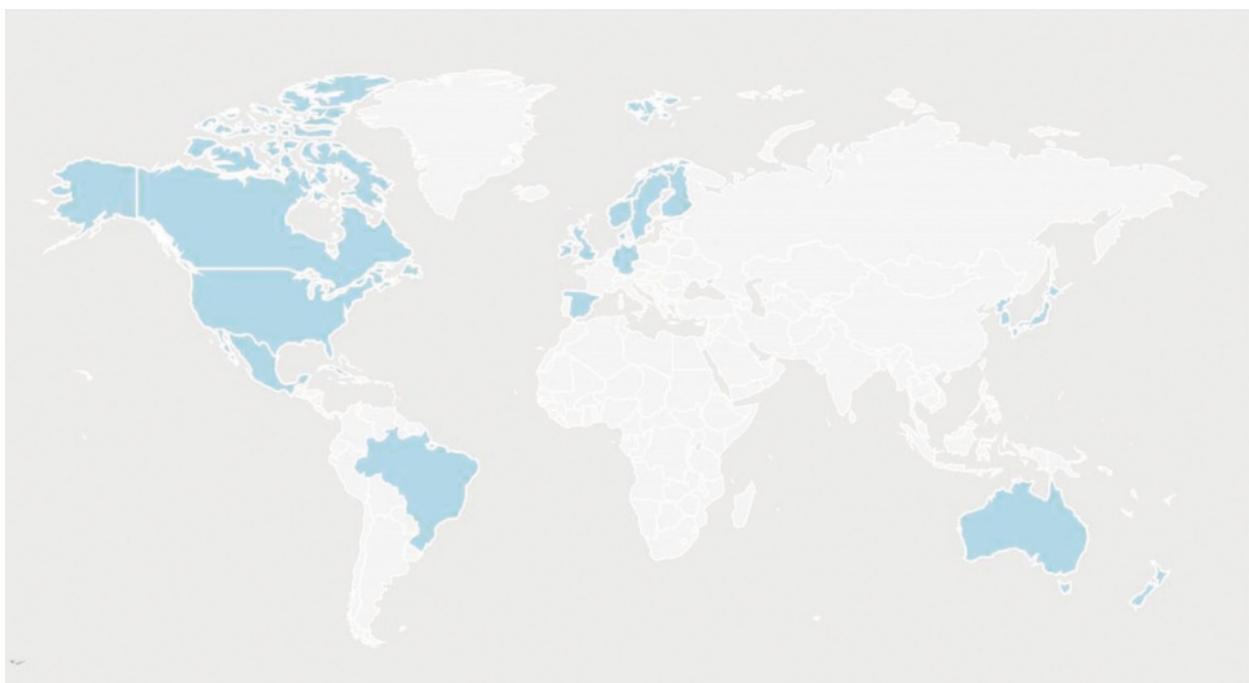


Fig 1-31 World xerostomia map. Marked in blue are geographic localizations with significant documented data on xerostomia prevalence.

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9. Key Points

- Progressive, irreversible and multifactorial, TW requires a comprehensive approach and a trained team to provide early diagnosis, preventive measures, and a patient-centered treatment path.
- TW is linked to lifestyle and general health conditions.
- Attrition and abrasion may, to a certain extent, be considered physiologic; erosion should always be regarded as pathologic.
- The estimated global prevalence of erosion has a huge variation, ranging from 0% to 100%.
- Sex distribution has shown a higher presentation in males.
- Ideal recovery from a TW impact requires patient re-education, a comprehensive treatment approach, a trained team, and ideally an early diagnosis that favors a conservative treatment modality.

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ISBN 978-1-78698-120-2

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A standard 1D barcode representing the ISBN 9781786981202.

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