



# Single-Implant Complications

**Biomechanics, Incidence, and Prevention**

**Charles J. Goodacre, DDS, MSD**

**W. Patrick Naylor, DDS, MPH, MS**



Single-Implant Complications: *Biomechanics, Incidence, and Prevention*



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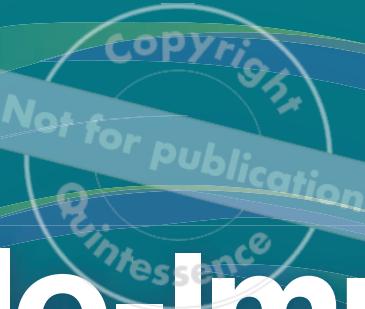
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## Biomechanics, Incidence, and Prevention

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# Dedications

To my wife, Ruthy (Goodacre), for her unwavering support and always positive personality. Without her at my side, I would not have been able to make this contribution to prosthodontics, nor the others that have occurred during my career.

- CJG

To my wife, Pennie (Naylor), for her patience and understanding during the many months devoted to this book, and her shared commitment to this contribution to the dental literature.

- WPN

# Contents

**Foreword by George A. Zarb** vi  
**Preface** vii  
**Acknowledgments** viii

- 1 Seven Common Complications with Single Implants** 1
- 2 Principles of Implant Biomechanics** 15
- 3 *Complication #1: Infraposition/Infraocclusion*** 35
- 4 *Complication #2: Interproximal Contact Loss*** 51
- 5 *Complication #3: Abutment Screw Loosening and Fracture*** 71
- 6 *Complication #4: Fracture of Single Implants*** 109
- 7 *Complication #5: Ceramic Chipping and Fracture*** 139
- 8 *Complication #6: Loss of Crown Retention*** 163
- 9 *Complication #7: Remake of the Implant-Supported Crown*** 179

**Index** 193



# Foreword

It is tempting to regard the first published book on osseointegration (OI) in 1985 as canonical. It ushered in a new, exciting era for diverse clinical approaches to managing tooth loss, which rapidly catalyzed additional research, scientifically based clinical developments, and new organizational initiatives devoted to its application. But it was Quintessence International that had the vision to launch a continuum of published scholarship in the field to ensure fulfilment of OI's educational mandate and global reach.

Per-Ingvar Bränemark's serendipitous observation/finding that a commercially pure titanium chamber used for studying *in vivo* blood flow in bone could not be separated from its host tissue launched his resolve to develop human clinical applications from his observations. What started as a proposed and scientifically viable solution for the edentulous predicament quickly evolved into an impressive range of clinical solutions for various tooth loss challenges.

It should also be readily acknowledged that Bränemark was indeed lucky to have the veracity of his biologic observation and early clinical research translated into both more surgical and prosthodontic initiatives by numerous clinical scholars, along with newly motivated authors from the global dental community, especially Drs Charles Goodacre and Patrick Naylor. Their much-respected clinical expertise in traditional recruitment of crown and bridge protocols to ensure functional and esthetic restoration of individual missing teeth was reflected in their teaching commitments and publications throughout their academic

careers—and well before OI opened the door to a new era of clinical management. They were also among the first to acknowledge the ecologic merits of a minimally intrusive therapeutic intervention that did not rely on removal of enamel on adjacent teeth—a first for a profession that somewhat belatedly came to terms with the reality that enamel is a nonrenewable resource!

Drs Charles Goodacre and Patrick Naylor have now focused their combined scholarship on a critical appraisal, indeed understanding, of the unique biomechanical features that must be understood to fulfil OI's applied promise for single-tooth replacement. They have also made us realize that their robust analysis of individual implant loading lends itself to equally fascinating collective loading considerations when planning multi-implant restorations.

This text is a compelling explanation of how prosthodontic treatment can be planned to ensure both efficacy and effectiveness of specific and scrupulously planned single-tooth implant replacement interventions. The OI technique has led to compelling new initiatives for the entire oral rehabilitation scenario, and this text's authorship provides exemplary scholarly focus on one of the most brilliant applications of Bränemark's research—replacement of the missing single tooth.

This is a thoroughly stimulating and informative book that deserves to be read by the entire dental profession.

**George A. Zarb, BChD, MS, DDS, MS, FRCRD  
Professor Emeritus, University of Toronto**



# Preface

**S**ingle-implant treatment has become an integral component of oral care provided in a wide range of clinical settings—from solo dental practitioner offices to multispecialty group practices. While some clinicians may limit the scope of their services to focus primarily on implant surgical placement or restoration, others choose to offer comprehensive treatment planning along with implant surgery *and* restorative dentistry in the same setting. Regardless of who does what and where, the clinical outcomes can be both transformative and life-changing.

The *transformative* phase was recognized early on with the replacement of a conventional three-unit fixed partial denture (supported by two teeth) with a single implant and crown in the edentulous area. The *life-changing* aspects of dental implants are evidenced by countless clinical reports in the dental literature. The treatments described may replace a single tooth, restore an edentulous arch, or rehabilitate an entire dentition. Individuals who are unable to wear conventional complete dentures today may be considered for one of several implant-supported complete-arch prostheses. In the case of a severely resorbed or atrophic maxilla, the introduction of zygomatic and pterygoid implants has heralded another major advancement over conventional complete denture prosthodontics thanks to more complex implant applications.

Irrespective of the scope of treatment, it is important that the implant-related procedures be guided by recognized surgical and prosthetic protocols and accepted clinical practices. Such groundwork will maximize the positive outcomes and minimize—if not prevent—complications with single implants, seven of which are identified and discussed in detail in this book.

The foundation for success relies on an understanding of implant biomechanics. The integration of dental implants (single root-form implants, zygomatic implants, wide-diameter implants, short implants, etc) and their varied applications are linked to more than

two dozen implant biomechanical principles. In fact, there are those who contend that “the principles of biomechanics represent the interactions between the body (tissues) and the forces acting upon it (directly or via different medical devices).”<sup>1</sup> When understood and followed, these concepts contribute to the high success rates now associated with implant-supported prosthetic restorations.<sup>1</sup>

With that philosophical framework in mind, a central theme of this book is an emphasis on the adherence to implant biomechanics by clinicians who engage in any aspect of dental implant treatment. Furthermore, readers will note that five key aims are also developed as a central focus of the book:

1. To raise greater awareness of six complications associated with providing patients with a single implant and crown along with a lesser-known seventh complication presented by the authors.
2. To share the incidence levels/ranges associated with each of these seven potential complications.
3. To provide an explanation of the biomechanics related to single implants and their crowns. Clinicians who plan and treat patients with these concepts at the forefront of their thinking can minimize, if not prevent, clinical complications from arising during or after the various stages of treatment.
4. To offer a means to manage the different complications once they have been identified. The resulting strategy is based on a simple four-step process.
5. To equip clinicians to prevent future complications through an increased awareness of the key elements of implant biomechanics that may have been overlooked or not given the consideration they merited during the various stages of treatment.

By the end of this book, readers should have a greater understanding of the important role implant biomechanics play in achieving and maintaining successful single-implant treatment. It is hoped that clinicians



will know how to address these three questions: What went wrong? Why did things go wrong? How could the complications have been prevented? Answering these three questions will not only help to understand why a given complication may have arisen but also shine a light on an appropriate implant treatment going forward.

## Reference

1. Manea A, Bran S, Dinu C, et al. Principles of biomechanics in oral implantology. *Med Pharm Rep* 2019;92(3):S14–S19.

## Acknowledgments

The authors extend their sincere thanks to Dr George A. Zarb for enriching this text with his enlightened perspective and thoughts conveyed across the pages of this book. To the generations of dentists who entered the dental profession after Dr Zarb's retirement, you missed the keen insight of his oral presentations, his masterful skills with the Queen's English, and the subtle humor his colleagues and friends enjoyed over the years. This is to say nothing of the enormous contributions he has made to prosthodontics at large and implant dentistry in particular. We cannot overstate the appreciation owed to Dr Zarb for his years

of dedicated service to clinical dentistry, dental education, and research as well as for the professionalism he has extended to patients, dental students, dental residents, and practicing dentists from around the world. Thank you, Dr Zarb.

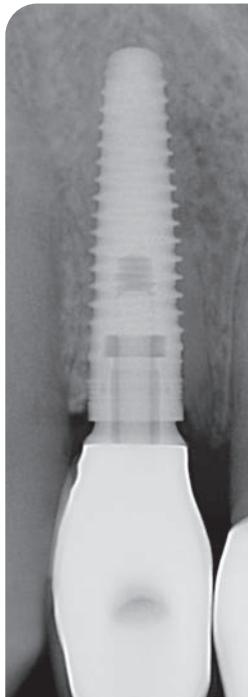
We also wish to acknowledge the dedication and hard work put forth by Quintessence Publishing Company, with particular thanks to William Hartman, former Executive Vice President and Director (now retired); Leah Huffman, Director of Editorial; Angelina Schmelter, Director of Production; and Sue Zubek, Graphic Designer.

# 1



## Seven Common Complications with Single Implants

Since first introduced some six decades ago, dental implants have forever altered the dental profession for the better. While survival rates are high, single-implant treatment is not yet synonymous with problem-free clinical outcomes. Citing published research, this chapter provides readers with a balanced overview of prevalence and incidence data, survival rates, and the seven complications associated with single implants.



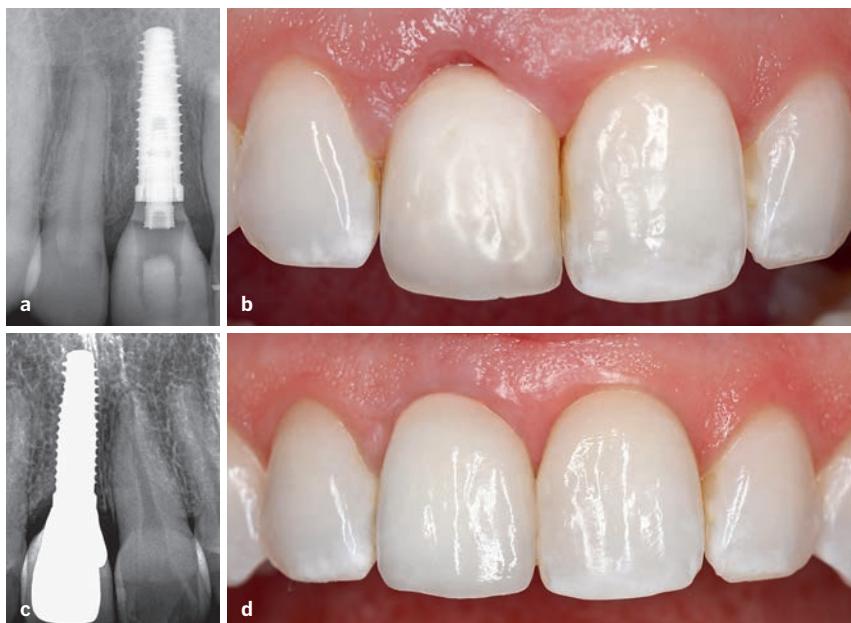
### Chapter Highlights:

- Single implants are widely used on a routine basis to replace lost or missing anterior and posterior teeth by general dentists and specialists alike.
- Based on previous reports and more contemporary literature, the seven most common complications are, in rank order, (1) infraposition/infra-occlusion, (2) interproximal contact loss, (3) abutment screw loosening and fracture, (4) fracture of the implant itself, (5) ceramic chipping and fracture, (6) loss of crown retention, and (7) remake of the implant-supported crown.
- Clinical success of single implants can be achieved by following biomechanical principles related to treatment planning, surgical placement, restoration, and patient management.
- A four-step process is proposed to minimize and/or prevent each complication: (1) diagnosis, (2) cause and effect, (3) management, and (4) prevention.

The successful integration of implants in bone, a process known as *osseointegration*, was first reported by the Swedish physician Dr Per-Ingvar Bränemark in his now-famous study involving rabbit tibia.<sup>1</sup> In 1965, Dr Bränemark placed his first oral implant.<sup>1</sup> Root-form dental implants were subsequently developed and later introduced to North America by Canadian prosthodontist Dr George A. Zarb and colleagues in the early 1980s. The history of this process of development, introduction, and acceptance in the dental community

has been described in many publications and can be found elsewhere.<sup>1-3</sup>

Fast-forward to today, where oral care involving dental implants is offered routinely around the world and provided in a wide range of dental settings from operating rooms to conventional dental operatories/surgeries. Single-implant therapy is particularly well established and offered by a diverse group of practitioners to replace a lost or missing tooth in the anterior (Figs 1-1 and 1-2) or posterior (Figs 1-3 and 1-4) regions of the mouth.<sup>4</sup>

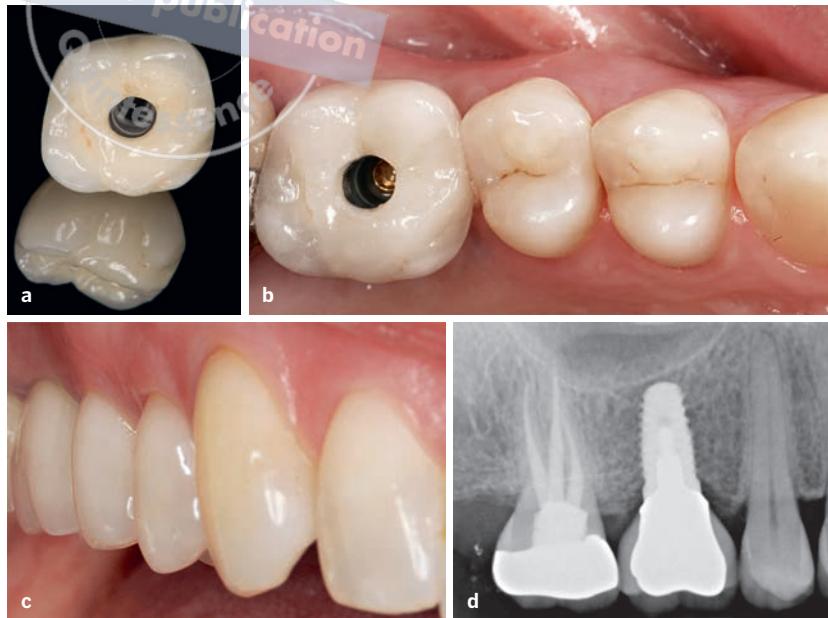


**Fig 1-1** This patient suffered a traumatic injury that resulted in such substantial damage to the maxillary right central incisor that it could not be retained. (a and b) An implant was placed immediately upon extraction of the tooth, and a provisional crown was delivered at the time of implant placement. The radiograph shows the temporary abutment in the implant and the provisional crown. The clinical photo shows the mucosa at the time of provisional crown delivery. (c and d) Definitive crown in place. The clinical photo shows the healed mucosa around the implant.

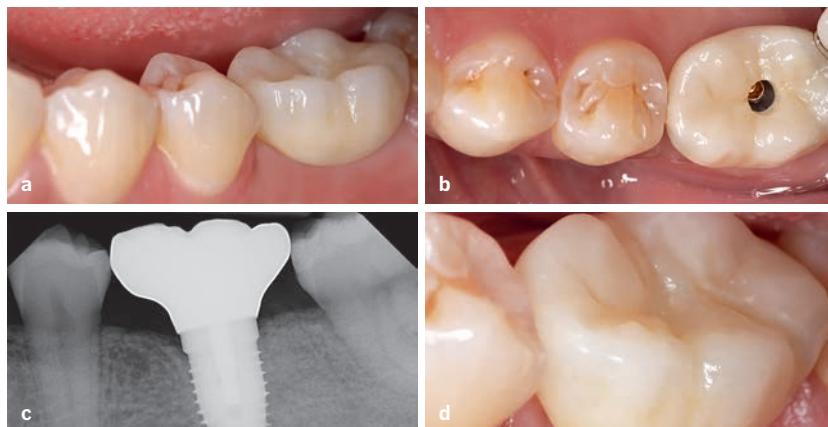


**Fig 1-2** (a) A zirconia abutment was cemented over a titanium-base (Ti-base) abutment using Multilink Hybrid Abutment high-opacity (HO O) cement (Ivoclar) and then attached to the implant using an abutment screw torqued to 35 Ncm. (b) The definitive crown was made using a CAD/CAM-milled zirconia coping that was veneered with a ceramic material (Cerabien ZR, Kuraray) and then cemented over the zirconia abutment using RelyX Unicem 2 resin cement (3M).

**Fig 1-3** (a) A metal-ceramic crown was fabricated for the maxillary first molar implant. (b) The crown was attached to the implant through the occlusal screw access channel. (c) Frontal view of the completed crown. (d) Periapical radiograph of the implant and crown.



**Fig 1-4** (a and b) The mandibular first molar was replaced with an implant and crown. (c) Periapical radiograph of the implant and crown. (d) Clinical photo after the occlusal access channel to the abutment screw was restored with composite resin.



## The Explosion in Single-Implant Use

It wasn't long ago that a three-unit fixed partial denture (FPD) would have been proposed for the replacement of a single missing anterior or posterior tooth. Today, however, clinicians routinely recommend a single implant and crown rather than an FPD, describing dental implant therapy as a well-accepted and time-proven treatment option. If called upon, clinicians can readily support this recommendation with decades of

research from evidence-based articles published in peer-reviewed scientific journals and numerous dental textbooks. Their proposed implant treatment is further supported thanks to a growing awareness among the general population that dental implants are a stable and long-term solution for tooth loss.

Needless to say, implant dentistry is an exploding field within dentistry. In fact, according to a 2018 article published in the *Journal of Dental Research*, in the United States alone, the prevalence of dental implant

**Table 1-1** The prevalence of dental implants in the United States (past and future projections), plus the projected value for the global market by 2030

Time period	Prevalence <sup>5</sup>	Projected global market value (USD) <sup>6-8</sup>
1999–2000	0.7%	–
2015–2016	5.7%	–
By 2026	Up to 23% (projected)	–
By 2029	–	\$6.52 to \$8.60 billion <sup>7</sup> (projected)
By 2030	–	\$9.62 billion <sup>8</sup> (projected)

use is projected to jump to 23% by 2026 from prior levels of 5.7% in 2016 and a mere 0.7% in 1999<sup>5</sup> (Table 1-1). What may be of even greater significance is there are no indications to suggest that this rapid growth trend will abate any time soon.

This expansion is further evidenced by the increased emphasis on training in implant surgery and related restorative procedures in dental educational programs in the United States and around the world. This is in addition to the demand for quality implant dentistry continuing education courses with classroom, laboratory, and clinical hands-on training.

In pure financial terms, projections put the “global dental implants market size” at ranging from \$6.52 billion (USD) to as high as \$8.60 billion by 2029<sup>6,7</sup> and up to \$9.62 billion (USD) by 2030<sup>8</sup> (see Table 1-1). North America accounts for the largest share of this dental implant market as of 2023, followed by Europe.<sup>6</sup>

At the same time, implant manufacturers continue to offer the dental profession new products, improved diagnostic tools,<sup>1</sup> and innovative technology coupled with privately and government-supported clinical research. In single-implant surgery, for example, the dental profession has witnessed an evolution from freehand implant surgical placement to enhancements using sophisticated surgical guides. Moreover, clinicians today now have the option to perform robotic implant surgery, not to mention the ability to replace

articulating media with computer monitoring of chewing patterns.<sup>1</sup>

Whether due to new and ever-improving technology, advances in clinical procedures, or expanded clinical applications, implant survival rates as high as 98.6% are not uncommon<sup>9-14</sup> (see Table 1-4). As a consequence, more clinicians are recommending single-implant therapy as the treatment of choice for the replacement of an individual tooth (see Figs 1-1 to 1-4). The growing public awareness of successful clinical outcomes has also spurred dental patients to seek implant treatment entirely on their own. Such behavior is in stark contrast to a few decades ago when dentists were still espousing the benefits of an FPD over a removable prosthesis during their patient treatment planning appointment.

## Remaining Challenges with Single Implants

While technical advances positively enhance the dental implant landscape, clinicians continue to encounter clinical challenges. In related articles published in 2003<sup>15</sup> and 2018<sup>16</sup> by one of the authors (CJG), six potential prosthetic complications were identified that affect single implants and their crowns (Table 1-2): abutment screw loosening, implant fracture, fracture or chipping of the ceramic veneer, loss of crown retention, open proximal contacts, and remake of the implant-supported crown.

Several years later, those same issues continue to surround single-implant treatment,<sup>17-36</sup> along with a seventh adverse clinical outcome not reported in two previous studies<sup>15,16</sup>: altered implant position (infraposition/infraocclusion) attributed to continued facial growth (especially in young patients). See Table 1-3 and Figs 1-5 to 1-14. Bear in mind that this latest finding is not actually “new” in the sense that it was only recently discovered. It is more accurate to report that it was previously identified but the condition was not as widely known or publicized as the other six complications. Depending on the complexity of the specific changes that take place, infraposition/infraocclusion can be quite difficult to manage. This newly added seventh complication can present a unique set of challenges and limitations for patients and clinicians alike (see chapter 3).

**Table 1-2** Prosthetic complications previously reported with implant prostheses<sup>15,16</sup>

Type of prosthesis	Number of complications
Implant overdentures	17
Implant fixed complete dentures	9
<b>Implant single crowns</b>	<b>6</b>
Implant FPDs	4

**Table 1-3** Seven complications linked to single implants and their crowns in order of incidence rates

Complication	Incidence range <sup>a</sup>	Relevant chapter in this book
1. Infraposition/infraocclusion (Fig 1-5)	17.6% <sup>17</sup> – 100% <sup>18-21</sup>	3
2. Interproximal contact loss <sup>b</sup> (Fig 1-6)	17% <sup>22,23</sup> – 66% <sup>24-26</sup>	4
3. Abutment screw loosening (Fig 1-7)/fracture (Fig 1-8)	1.0% <sup>27</sup> – 14.7% <sup>28</sup> /0.06% <sup>29</sup> – 1.2% <sup>30</sup>	5
4. Single-implant fracture (Fig 1-9)	0.20% <sup>31</sup> – 0.92% <sup>32</sup> /12.7% <sup>33c</sup>	6
5. Ceramic chipping (Fig 1-10)/fracture (Fig 1-11)	0.0% <sup>34</sup> – 11.8% <sup>35</sup> /0.0% <sup>28</sup> – 2.9% <sup>28</sup>	7
6. Loss of crown retention (Fig 1-12)		
<i>Titanium implants (definitive cement)</i>	0.0% – 4.3% <sup>28</sup>	8
<i>Zirconia implants (definitive cement)</i>	0.0% – 2.9% <sup>37</sup>	8
7. Remake of the implant-supported crown (Figs 1-13 and Fig 1-14)	0.0% <sup>35</sup> – 1.9% <sup>36</sup>	9

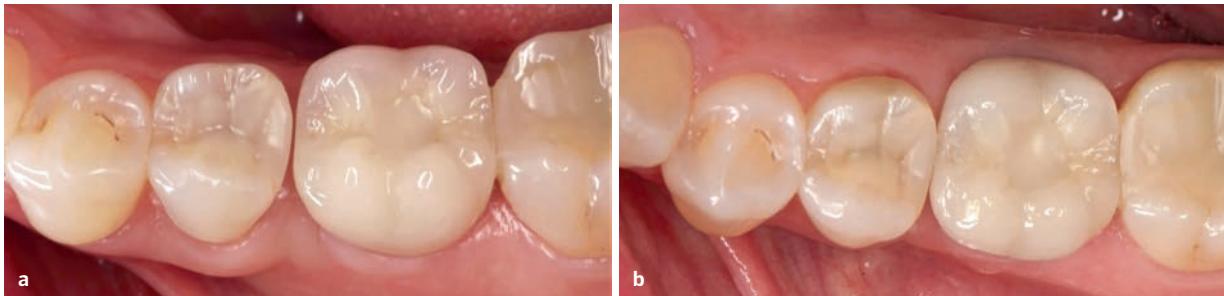
<sup>a</sup>Due to wide variations in the outcomes data, incidence ranges are reported rather than a mean rate.

<sup>b</sup>Technically, Kandathilparambil et al<sup>23</sup> reported a 15% incidence rate but with 40 mandibular first molars and the patients wore an Essix retainer. The 17% incidence rate for the low end of this range appears in this table because the French et al<sup>22</sup> study involved a much larger sample size of 4,325 implants. This is likely more representative of the low end of the range.

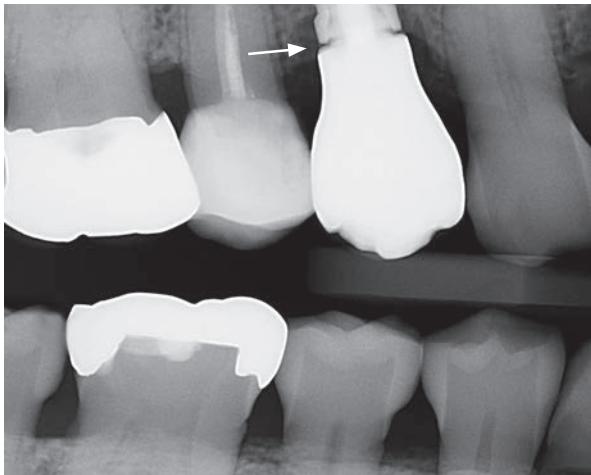
<sup>c</sup>Chitumalla et al<sup>33</sup> reported a 12.7% incidence rate with a much smaller test population (n = 157) than Lee et al<sup>32</sup> and their subjects included bruxers.



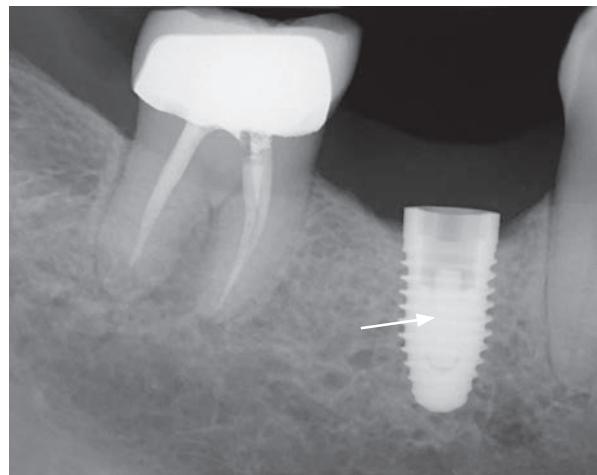
**Fig 1-5** The maxillary right lateral incisor implant was placed before facial growth was completed, and the crown is now infrapositioned and out of occlusion with the opposing teeth after 9 years in function. This is an example of complication #1 (infraposition/infraocclusion).



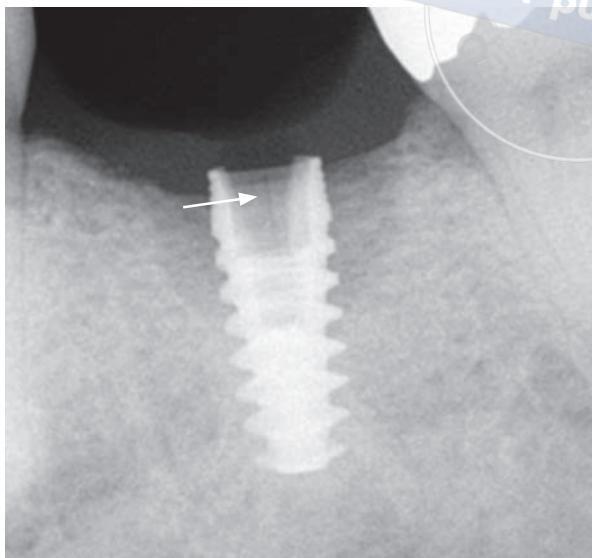
**Fig 1-6** (a) Six years after placement of the crown on the first molar implant, the mesial interproximal contact opened and food was collecting in the space. (b) The composite resin restoration on the distal surface of the second premolar was replaced to reestablish the proximal contact. This is an example of complication #2 (interproximal contact loss).



**Fig 1-7** The bitewing radiograph shows a maxillary first premolar implant crown where the abutment screw became loose. Space (arrow) is now visible between the crown and the implant on the radiograph. This is an example of complication #3 (abutment screw loosening).



**Fig 1-8** The arrow points to the apical portion of a fractured abutment screw still lodged inside the implant. Note that the implant is positioned toward the mesial aspect of the edentulous space rather than being centered. Because of this positioning, the crown had an extension distal to the implant that placed adverse leverage on the crown, which then led to abutment screw fracture. This is an example of complication #3 (abutment screw fracture).



**Fig 1-9** The combination of a bruxing habit with a distally positioned implant and a nonworking-side occlusal interference caused this implant to fracture (arrow). This is an example of complication #4 (single implant fracture).



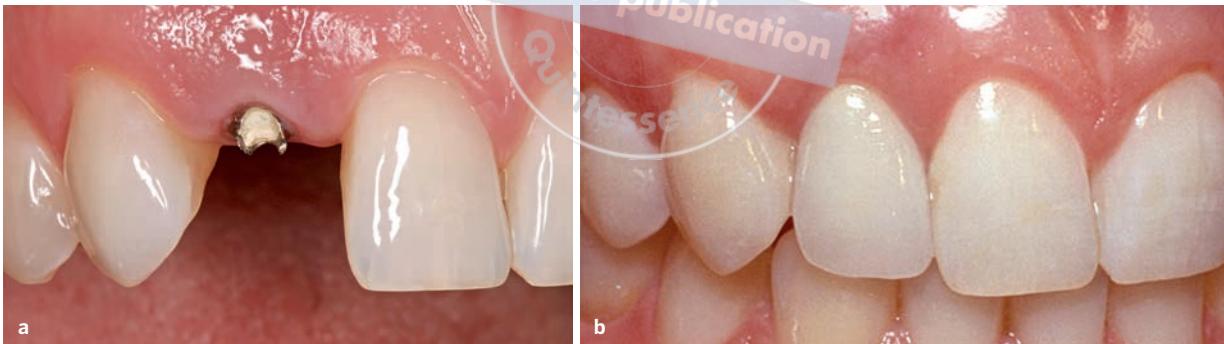
**Fig 1-10** The superior portion of the ceramic veneer on this zirconia all-ceramic restoration is chipped. The cause of the chipping was assumed to be occlusal forces, although an occlusal interference may have been responsible for the chipping. This is an example of complication #5 (ceramic chipping).

**Fig 1-11** A portion of the facial aspect of this monolithic zirconia crown on the maxillary second molar implant has fractured from the underlying abutment. The crown must be replaced. This is an example of complication #5 (ceramic fracture) and complication #7 (remake of the implant-supported crown).



**Fig 1-12** (a) The crown on the maxillary left canine implant came loose due to the use of a provisional cement and an abutment with a smooth surface and substantial faciolingual convergence. Both of these factors resulted in less than ideal retention. (b) Facial view of the definitive crown after recementation with a resin luting agent. This is an example of complication #7 (remake of the implant-supported crown).





**Fig 1-13** (a) The abutment attached to the maxillary right lateral incisor implant fractured, necessitating a remake of the abutment and crown. (b) After whitening the teeth, a new abutment and crown were placed. This case is also an example of complication #7 (remake of the implant-supported crown).



**Fig 1-14** (a) Both maxillary central incisors were extracted with implants placed immediately, resulting in substantial mucosal recession. The patient was not satisfied with the esthetic result. The central incisor implant-supported crowns were overcontoured cervically. Gingival recession followed the extraction of the adjacent natural teeth and implant placement. (b) To help improve the esthetic outcome, the two single-implant crowns were remade by one of the authors (CJG) but with flat submucosal contours that included the addition of cervical pink porcelain. The reduced cervical crown contours permitted the mucosa to migrate incisally, but it required an entire year for this positive tissue change to occur. While the use of pink porcelain did not produce an ideal esthetic result, it did improve the two implant-supported central incisor crowns to the point where the patient was satisfied with the final result. This is another example of complication #7 (remake of the implant-supported crowns).

## Single-Implant Survival Rates and Potential Complications

While FPDs remain an option for patients with financial constraints, limited access to implant care, personal preferences against surgical treatment, or health issues, a well-planned single implant and crown can be a more successful and advantageous treatment modality. Clinicians can offer single implant treatment with confidence knowing their recommendation is backed by decades of evidence-based research.

Select examples of published research reports with positive short-term and long-term survival rates of single implants appear in Table 1-4.<sup>9-14</sup> The data drawn from these six articles range from a 4-year survival rate

of 97% (for 459 patients) to an 18-year period with a 98.6% survival rate.<sup>9,11</sup> These studies represent data from nine nations collected over 19 years (2000 to 2018) and provide a global perspective. However, it is important to note that (1) survival rates may vary based on the experience level of the clinician and (2) complications still occur despite excellent survival rates.<sup>12</sup>

To put this in a contemporary context, although a single implant may remain osseointegrated for many years, that does not mean complications won't arise during that time. It is this duality (survival vs complications) that clinicians should bear in mind when planning and proposing single-implant treatment to their patients. In a 2021 article, Kaur et al<sup>38</sup> pointed out that while published reports often include implant survival data, readers do

**Table 1-4** Select reports with single-implant survival rates

Authors	Year	Survival period	Survival rate (%)	No. of implants (n)
Creugers et al <sup>9</sup>	2000	4 years	97.0%	459
Krennmaier et al <sup>10</sup>	2010	5 years	98.3%*	541
Andersson et al <sup>11</sup>	2013	18 years	96.8%	65
Pjetursson et al <sup>12</sup>	2012	5 years	94.5%	465
Pjetursson et al <sup>12</sup>	2012	10 years	89.4%	69
Mozzati et al <sup>13</sup>	2015	10 years	90.5%	181
Beschnidt et al <sup>14</sup>	2018	5 years	98.6%	271

\*Involved “root-shaped screw-type dental implants.”<sup>10</sup>

not always come away with a “full picture of the rate of complications.” To appreciate this particular perspective, it is helpful to separate the two concepts—survival and complications—and analyze them individually.

### Survival

Take a moment to reflect on the meaning of the word *survival* as it is applied to single dental implants. Think of this term as indicating the percentage of root-form dental implants that remain functional over a specified length of time. In other words, how many implants “survived” to the end of a study? None of the studies included in Table 1-4 reported 100% survival. For a variety of reasons, a certain number of implants were lost (failed) during each study period. In a 2019 article, Manea et al<sup>39</sup> summed it up rather succinctly when they wrote that “no therapy is without failure risk.”

Even when implant survival rates approach 99% (see Table 1-4), there will be a real number of clinical failures—1%. That may be a very small percentage, but think in terms of the sheer volume of single implants placed

every year around the world. Even 1% of that number would translate to a sizeable number of affected patients.

According to some non-peer-reviewed publications, dental patients receive between 3 and 5.5 million dental implants in the United States annually.<sup>40</sup> For the sake of illustration, let’s assume a figure of 3 million implants placed annually represents a reasonable estimate just for the United States and apply a survival rate of 99%. In the best of scenarios, 30,000 would be the estimated number of nonsurviving implants each year. That is no small number of implants in need of replacement. Should the number of implants placed be closer to 5.5 million per year, the estimated number of annual failures then jumps to 55,000. If the actual survival rate is below 99%, the estimate of failed single implants becomes even higher, and this is just for the United States. Furthermore, these calculations pale in comparison to the estimate of “up to half a million” implant failures in 2021 reported by Kaur et al,<sup>38</sup> who considered longitudinal survival rates of osseointegrated dental implants to range from 90% to 95%.

## Types of Implant Complications

Nonetheless, based on the long-term data in Table 1-4,<sup>9-14</sup> the reported survival rates for simple-implant treatment range from 89.4% to 98.6%. When discussing potential treatment with patients, the underlying concept to emphasize is that implant survival data are high, but there should be no implication of 100% survival for 5 years, 10 years, or longer for single implants and their crowns.

Now we've covered the survival side of single-implant treatment. Next let's review the complications linked to single implants and the reported incidence ranges for those complications.

### Complications

Problems can and do arise with implants and their crowns. Look at Table 1-3 again. Irrespective of how long an implant has been functioning in place, these seven complications may arise. Once diagnosed, they will have to be addressed during the period of their survival (or what we may refer to as their *service life*). Even with a very low incidence rate, an adverse outcome of any sort can pose significant difficulties for the patient and challenges for the clinician trying to resolve it.

That being said, fracture of the single implant is the only complication that truly impacts implant survival. Of course, abutment screw fracture could lead to the need to replace an implant should retrieval of the screw fragment(s) not be possible, but the remaining complications generally pertain to the status of the implant-supported crown and can usually be managed without having to remove and replace the implant itself. In other words, implant survival is not necessarily negatively impacted by all seven complications in the same way.

Again, it is helpful to think of implant survival and implant complications as separate but related concepts. As Manea et al<sup>39</sup> once pointed out, "A good understanding of the biomechanics involved in oral implantology can lead to higher success rates in implant-supported prosthetic restorations." That increased success can in turn be accompanied by fewer technical complications when there is greater compliance with implant biomechanics, as discussed in this book.

In the 2021 article by Kaur et al<sup>38</sup> referred to earlier, the authors wrote about two types of implant complications: biologic and prosthetic. In an often-cited 2012 systematic review, Jung et al<sup>41</sup> compared and assessed three types of single-implant complications: (1) biologic, (2) technical, and (3) esthetic. Other popular labels for complications mentioned in the literature include surgical, mechanical, phonetic, etc. Under each of these broad groupings, authors may then itemize various clinical experiences in different "categories."

Continuing with examples of biologic complications mentioned by Kaur et al,<sup>38</sup> the authors described two categories of potential outcomes: peri-implant mucositis and peri-implantitis. On the other hand, Jung et al<sup>41</sup> identified seven different categories of complications under the biologic umbrella: soft tissue complications, signs of inflammation, mucosal inflammation, mucositis, bleeding, suppuration, and soft tissue dehiscence. Jung et al<sup>41</sup> also mentioned five technical categories of complications and listed them in rank order of occurrence as abutment-loosening, screw loosening, loss of retention, fracture of the crown ceramic veneer, and implant fracture. Under the umbrella of esthetic complications, Jung et al<sup>41</sup> included three items: soft tissue dehiscence exposing the crown margin, suboptimal color of the restoration, and general esthetic issues (papilla height for example). These authors also pointed out the lack of standardization of criteria used to assess and evaluate esthetic complications. Goodacre et al<sup>15,16</sup> chose to divide complications into eight types: surgical, implant loss, bone loss, peri-implant soft tissue, mechanical, esthetic, phonetic, and prosthetic.

Note that these categories are still sufficiently broad to allow room for even more detailed information. Take Jung et al's category of "signs of inflammation,"<sup>41</sup> for example. Are those signs localized or generalized, acute or chronic, minor or severe, treatable nonsurgically or surgically, and so on? Given this complexity, it is recommended to look for specifics when reading reports that describe patient situations that fall into one or more of these types and categories of complications linked to single implants.

## Incidence and Timing of Complications

### Incidence

Aside from knowing which adverse changes may occur over time, another variable clinicians should be aware of is the incidence (frequency) with which the different postoperative complications reportedly may arise (see Table 1-3). One could reasonably deduce that the incidence data are more accurate when a complication is tracked and reported in a larger number of studies. With a limited number of reports, it is not possible to know whether that specific adverse outcome is a rare occurrence or not, until such a finding is more widely reported or identified in larger patient populations.

### Timing

Kaur et al<sup>38</sup> described implant complications by combining categories with time. More specifically, the authors mentioned clinical scenarios in which the biologic and prosthetic complications included adverse outcomes that were “early” and “late” in the course of treatment. The use of descriptive labels (type and category) coupled with time references (early vs late), even if slightly different from one another, can be helpful when clinicians read and assess comparable clinical findings in other publications. This information should also prove valuable for practitioners who eventually plan to or are currently providing implant treatment.

## Multiple Concurrent Complications

An added consideration is that several implant complications can occur simultaneous to one another. In other words, clinicians should not focus solely on the incidence rates of opening proximal contacts, abutment screw loosening, or loss of crown retention but also think of these potential complications in the aggregate as overall frequency. In the event that any complication is encountered, indications of the remaining six should be looked for and evaluated.

In a 2012 article, Camargos et al<sup>42</sup> combined the complication data of three types (inflammatory, prosthetic, and operative) to arrive at an overall complications rate of 29.6%. On the other hand, Kaur et al<sup>38</sup> reported a 10.8% overall incidence of technical/mechanical complications

for single implants. Recall that the categories of complications they referred to actually included implant screw loosening, implant screw fracture, prosthesis fracture, debonding of the prosthesis, and/or implant fracture.<sup>38</sup> Citing previously published reports, they also described the incidence rates of peri-implant mucositis as occurring in up to 65% of patients, concluding that the incidence rate of peri-implantitis could range from 10% to as high as 47%.<sup>38</sup>

## Managing Clinical Complications from Diagnosis to Prevention

If you place and/or restore enough single implants, you can expect to encounter one or more of the seven implant-related complications listed in Table 1-3. When considering how to manage each implant complication, the authors recommend following a four-step process (Box 1-1): (1) diagnosis, (2) cause and effect, (3) management, and (4) prevention.

### How should you begin?

Any complication management begins with a comprehensive oral examination to locate and identify each problem to be evaluated. Never be surprised if you find more than one complication or a potential complication that is developing. This oral examination will help you achieve a diagnosis as to what happened (step 1), and the cause and effect (step 2) can then be determined. Based on the information collected and the current status of the patient, realistic options can be weighed to manage the complication (step 3). It is essential that you understand what occurred before proposing and initiating treatment in order to manage the complication effectively and prevent future problems (step 4). You don't want this complication to arise again with this same patient or in other patients whom you may treat similarly in the future (see Box 1-2).

### 1. Diagnosis

When the patient presents with a problem or simply for a follow-up appointment, it is prudent to update the patient's medical history, obtain blood pressure readings, and perform a comprehensive oral examination. As part of this assessment, determine if there are obvious

**Box 1-1 Four steps to managing complications with single implants**

1. Diagnosis
2. Cause and effect
3. Management
4. Prevention

indications that any principles of implant biomechanics have been compromised. Those principles, 25 in all, are presented and discussed in detail in chapter 2. Keep in mind that multiple small problems can compound and even worsen over time, particularly if not addressed early. Always classify complications by type and category and, when possible, designate them as early or late changes. Being organized in your documentation will help you avoid bigger problems down the line.

**2. Cause and effect**

A cause-and-effect perspective is helpful when evaluating each negative outcome (the effect) and the biomechanical principle(s) that may have been overlooked or not followed (the cause). With some patient situations, treatment may have violated multiple biomechanical principles and thus warrant management in more than one way.

It is important to understand that adverse outcomes do not need to be commonplace, provided treatment complies with and does not violate any of the recognized principles of implant biomechanics. In other words, it is not unreasonable to assume that complications can be avoided, and those complications that do arise can be managed with varying degrees of success. Make a concerted effort to identify and correct the root cause(s) that may involve knowingly or unknowingly violating certain biomechanical principles.

**3. Management**

Once a complication has been diagnosed, evaluate the extent of any adverse changes and come up with a list of options to achieve resolution, recognizing that there may be circumstances when simple corrective

steps are no longer possible. The nature and/or extent of some problems can be so extensive that removal of the entire assembly (implant and crown) is advisable. But in many instances, simply retightening or replacing a screw, recementing a crown, or closing a proximal contact by adding or replacing an adjacent restoration or the implant-supported crown is sufficient. Keep in mind that based on the nature of the complication and the potential delay in addressing it, peri-implant mucosal inflammation, localized infection, mucosal recession, bone loss, and other periodontal conditions may develop and require adjunctive periodontal therapies before implant retreatment.

Think of the management of complications as a process unto itself with degrees of engagement from basic to challenging. Be mindful of the “overall complications” rate as an acknowledgment that more than one problem may have to be addressed and resolved. In a similar vein, expect to encounter patient situations where significant time, effort, and expense would need to be expended to “save” an existing crown or implant. Under those circumstances, it might be more prudent and practical to declare the situation a failure and proceed directly to retreatment. Of course, such clarity is invariably seen in hindsight and often only with the benefit of years of experience managing numerous unfavorable patient treatment outcomes.

**4. Prevention**

Once a clinical complication has been identified, diagnosed, and managed with some sort of “fix” (remedy) or a recommendation to retreat, a postoperative assessment should be undertaken to focus on questions specific to the complications involved (Box 1-2). Such a strategy helps to minimize—if not prevent—recurrences,

**Box 1-2 Three key questions to answer when assessing implant complications**

1. What went wrong?
2. Why did things go wrong?
3. How could this situation have been prevented?

assuming the original treatment was not aligned with one or more key biomechanical principles associated with single-tooth implants.

Make a concerted effort to learn from each patient situation to avoid future missteps in the planning and execution stages that might otherwise lead to a repetition of those same complications. After all, the overall goal is to provide implant treatment with a long service life unencumbered by clinical complications.

## Conclusion

Diagnosing and correcting implant complications can be challenging for clinicians, not to mention inconvenient and costly for affected patients. This is particularly true when clinicians are unaware of the potential for specific types of complications to occur. While 100% implant survival with every patient is an admirable goal, implant loss (failure) remains a potential risk, if only to a limited degree. It is unrealistic to expect a 0% complication rate over the life of an implant.

For the benefit of all concerned, understanding and applying the fundamental principles associated with single-implant biomechanics go a long way in minimizing complications, if not preventing them from arising in the first place (see chapter 2). Citing published research, this chapter provided an overview of those complications that continue to be linked to single implants and their crowns. Armed with data collected from your own implant patients, you may improve treatment outcomes once you learn how to diagnose complications shortly after they arise, manage each issue properly, and take appropriate steps to prevent those unplanned outcomes from recurring.

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# Index

Page references followed by "f" denote figures, "t" denote tables, and "b" denote boxes.

## A

Abutment(s)  
 angled screw channel with, 76, 76f  
 antirotational features of, 71, 71f, 74  
 CAD/CAM-milled, 170f  
 custom, 27f, 169f-170f  
 design advancements for, 74-76, 75f  
 diameter of, 122  
 early types of, 71, 71f  
 external hexagonal antirotational features of, 74, 75f  
 fit of, 78f  
 internal hexagonal antirotational features of, 74, 75f  
 third-party, 21f, 80  
 titanium, 2f, 21f, 170f-171f, 189f  
 total occlusal convergence of, 169f  
 zirconia. See Zirconia abutments.

Abutment screw  
 access to  
 with cemented crowns, 92-93  
 with screw-retained crowns, 90f-91f, 90-92  
 damage to, 91, 91f  
 gold, 77f  
 head of  
 depth of, 91, 91f  
 illustration of, 90f  
 removal of, 90-91  
 slot created in, 90  
 location of, 94-95  
 loose, replacement of, 105-106  
 in mandibular molars, 94f  
 modification of, 97  
 in molar crown, 79f  
 occlusal opening, 92, 93f  
 overtightening of, 84  
 replacement of, 91  
 retightening of, 85, 88, 93, 105, 155, 186

retrieval and assessment of, 92-93  
 securing of, for cemented crown, 77-80, 77f-81f  
 settling effect of, 85  
 tightening of  
 biomechanics of, 84-85  
 description of, 76  
 torque recommendations for, 77  
 wear of, 91, 91f

Abutment screw fracture  
 before abutment screw loosening, 94, 104, 115, 119f  
 access to  
 with cemented crowns, 92-93  
 with screw-retained crowns, 90f-91f, 90-92  
 biomechanical factors, 104-105  
 cause and effect for, 104-105, 187  
 diagnosis of, 104  
 fractured screw removal  
 implant damage caused by, 97, 98t  
 kit for, 96-97, 96f-97f  
 reversal of screw before, 95, 95f  
 risk-based approach to, 98t  
 illustration of, 6f, 26f  
 incidence of, 5t, 72, 73t, 74  
 indicators of, 106  
 management of, 93-97, 105-106  
 minimizing of, 104-106  
 prevention of, 106  
 remaking of implant-supported crown because of, 186-187, 187f  
 screw modification for, 97  
 torque as cause of, 29

Abutment screw loosening  
 abutment screw fracture before, 94, 104, 115, 119f  
 angulated screw channel crowns and, 89-90  
 biomechanical factors, 104-105  
 bruxism as cause of, 85, 98  
 cause and effect for, 104-105  
 causes of, 84

diagnosis of, 104  
 factors contributing to, 85-89, 86f-87f, 88b  
 illustration of, 6f, 26f, 119f  
 implant positioning and, 86f  
 incidence of, 5t, 72-74, 73t-74t, 106  
 joint-separating force as cause of, 84  
 management of, 90-93, 105-106  
 mechanical overload as cause of, 105  
 minimizing of, 104-106  
 prevention of, 106  
 remaking of implant-supported crown because of, 186-187  
 replacement of screw because of, 105-106  
 retightening of abutment screws after, 93, 186  
 timing of, after crown placement, 88-89  
 torque as cause of, 29

Abutment-crown combination  
 description of, 21f, 84  
 fit of, 128-129

Abutment-crown margin, 175

Abutment-implant fit, 128-129

Active tactile sensibility, 151

All-ceramic crowns  
 aging of, 184  
 cementation of, 175  
 chipping and fracture of, 139, 147  
 materials for, 149b  
 monolithic, 148, 148t, 154  
 veneered, 148, 148t, 154

Angled/angulated screw channel  
 crowns, 89-90  
 description of, 76, 76f

Anterior crown, eccentric contacts on, 103

ASF. See Abutment screw fracture.

ASL. See Abutment screw loosening.

**B**

Beam-type torque wrenches, 81f, 82, 83f  
 Biologic complications, 10  
 Biomechanics. See Implant biomechanics.  
 Broken-arm torque wrenches, 82, 82f-83f  
 Bruxism. *See also* Parafunctional habits.  
 abutment screw loosening caused by, 85, 98  
 eccentric occlusal contacts affected by, 102  
 mandibular anterior teeth wear from, 20f  
 occlusal guard for, 18, 20f  
 single-implant fracture caused by, 110, 118f, 130-131

**C**

Cement  
 excess, 175, 175f  
 extrusion of, 25-26

loss of crown retention and, 165t, 166  
 provisional, 26, 166

Cemented crowns  
 abutment screw for  
 access to, 92-93, 92f-93f  
 securing of, 77-80, 77f-81f

interproximal contacts for  
 adjustments in, 80-81  
 description of, 66  
 loss of retention for, 168t  
 on maxillary left lateral incisor, 184f  
 screw-retained crowns versus, for cement extrusion prevention, 25

10 degrees of occlusal convergence and 4 mm of vertical height for, 26, 27f

Centric occlusal contacts, 61f, 100, 153

Centric occlusion, 160

Ceramic chipping and fracture  
 all-ceramic crown, 139, 147  
 cause and effect, 160  
 clinical implications of, 161  
 diagnosis of, 160  
 evidence of, 152-153  
 factors contributing to, 153b, 153-154  
 grading of, 141-143, 155, 187  
 history-taking for, 154  
 illustration of, 7f  
 incidence of, 5t, 140, 143, 144t-146t, 145-146, 148t-149t  
 major, 139, 139f, 154-155  
 management of, 160-161  
 minor, 139, 139f, 154, 155f  
 moderate, 155  
 monolithic crowns, 146-149, 148t, 154  
 occlusal forces as cause of, 160  
 oral examination for, 154  
 overview of, 139-140  
 parafunctional habits as cause of, 160  
 prevention of, 161  
 remaking of implant-supported crown because of, 187-188  
 steps to minimize, 160-161  
 types of, 154-156  
 veneered crowns, 146-149, 148t, 154  
 zirconia abutment fracture, 157-159, 157f-159f

Children  
 implant failure versus success in, 47  
 implant placement in  
 challenges associated with, 35-36, 42-43  
 complications of, 45-46  
 timing of, 44-45  
 parental pressure, 43  
 permanent tooth loss in, 42  
 tooth agenesis in, 42  
 treatment planning considerations in, 43

Closed interproximal contact, 56

Complications. *See also specific complication.*

- biologic, 10
- biomechanical principles related to, 33t
- cause-and-effect perspective of, 12
- concurrent, 11
- diagnosis of, 11-12
- esthetic, 10
- incidence of, 11
- last tooth in the arch, 133, 133f-134f, 154-156
- management of, 11-13, 12b
- oral examination for, 11
- prevention of, 12-13, 32, 33b
- questions for assessing, 12b
- technical, 10-11
- timing of, 11
- types of, 5t, 10, 16t, 32, 181b

Crown(s). *See also* Implant-supported crowns.

- adjacent, splinting of, 18, 20f
- adverse leverage on, 126-127, 127f, 133f
- all-ceramic. *See* All-ceramic crowns.
- angulated screw channel, 89-90
- cemented. *See* Cemented crowns.
- centering of implant beneath, 20, 21f, 23, 119f
- ceramic component of, 156-157
- complete, 179
- design of, 156
- dislodgement of, 183f
- distal extension of, 23, 24f, 87, 134f, 182f
- fabrication of, 156
- loss of retention. *See* Loss of crown retention.
- mesiodistal adjustable, 66
- mobility assessments, 172-173
- monolithic
  - chipping of, 146-149, 148t-149t, 154
  - materials for, 149
- occlusal adjustment of teeth next to, 31, 32f
- occlusal contacts with, 151
- placement of, abutment screw loosening after, 88-89
- posterior
  - cuspal inclination relative to torque, 117-118
  - eccentric contacts on, 101-102, 103f
  - faciolingual dimension of, narrowing of, 24, 25f
- recementation of, 174-175
- remaking of, 180-181, 183
- screw-retained. *See* Screw-retained crowns.
- seating of, 86, 86f
- tall, 23, 85, 86f, 158
- veneered
  - chipping of, 146-149, 148t-149t, 154
  - materials for, 149
- vertical space dimension effects on selection of, 171-172

Crown height space, 172b

Crown-abutment combination

- description of, 21f, 84
- fit of, 128-129

Crown-to-implant ratio, 23, 24f, 126, 127f

**D**

- Decementation, 189
- Delayed placement, of implants, 18, 19f, 43
- Dental floss technique, 59
- Dental implants. *See* Implant(s).
- Dial indicator torque wrench, 82f, 83
- Digital torque wrenches, 82f, 83
- Discrimination ability, 151
- Distal movement, of teeth, 61-62

**E**

- Eccentric contacts
  - on anterior crown, 103
  - description of, 100, 101f, 153
  - on posterior crown, 101-102, 103f
- Esthetic complications, 10

**F**

- Facial growth
  - implant placement in patients undergoing, 35-36
  - in older patients, 39
- Fixed complete denture, 71f
- Fixed partial dentures
  - indications for, 3
  - metal-ceramic, 141
- Floss resistance test, 59
- Fractures. *See* Ceramic chipping and fracture; Single-implant fracture.
- Freehand implant surgery, 126-127
- Friction-style devices, 83
- Furcal bone, posterior implants in, 28, 28f

**G**

- Gender, infraposition/infraocclusion and, 46-47
- Growing and developing patients. *See* Children; Young adults.
- Growth spurts, 43
- Guided surgery
  - restricted vertical space for surgical access during, effects on
  - implant loading, 127, 128f, 128t
  - surgical guide for, 19f, 126-127

**H**

- Hyperocclusion, 152, 160

## I

ICL. *See* Interproximal contact loss.

Implant(s)

- angled, 95f
- complications of. *See* Complications.
- freehand surgical placement of, 4
- global market for, 4
- horizontal offset of, 21, 22f
- large-diameter, 24f
- last tooth in the arch replaced with, 133, 133f-134f, 154
- manufacturers of

  - advancements by, 4
  - original components from, versus third-party components, 20, 21f, 80

- mobility of, 172
- overloading of, 115
- in pediatric patients, 35
- placement of. *See* Implant placement.
- prevalence of use, 3-4, 4t, 9
- proprioception with, 150-152
- risks associated with, 32
- robotic surgery for, 4
- service life of, 10
- single-tooth. *See* Single implants.
- surgical guide for, 127, 127f
- survival rates for, 4, 9t, 9-10
- tactile perception with, 150
- tactile sensibility with, 132, 150-151
- vertical mouth opening measurements for, 18, 19f, 129f
- vertical space dimension effects on crown selection, 171-172
- wide-diameter, 128, 129f
- zirconia, 5t, 164, 165t

Implant biomechanics

- complications associated with, 33t
- general guidance

  - delayed placement, 18, 19f
  - occlusal guard, 18, 20f
  - overview of, 17b, 18
  - splinting of implant-supported crowns, 18, 20f
  - vertical mouth opening measurements, 18, 19f-20f, 129f

- noncompliance with, 104
- overview of, 15
- principles of, 16-32, 17b
- prosthetic procedures

  - overview of, 17b
  - torque application, 29, 29f

- single-implant failure caused by, 113f
- surgical procedures

  - interproximal contacts, 29, 30f
  - molar implant placed in furcal bone, 28, 28f
  - occlusion adjustments, 30f, 30-31, 32f

- overview of, 17b
- two single implants placed to support one molar crown, 28, 28f
- treatment planning and restoration design

  - centering of implant beneath crown, 20, 21f, 23, 119f
  - crown-to-implant ratio, 23, 24f
  - cuspal inclinations with heavy occlusal forces, 23, 25f
  - distal positioning, 23, 23f
  - horizontal offset of implant, 21, 22f
  - larger-diameter implant in molar sites, 23, 24f
  - long axis of posterior implant aligned with opposing functional cusp, 21, 22f
  - manufacturer's original components versus third-party components, 20, 21f, 80
  - minimizing crown extension distal, 23, 24f
  - narrowing of faciolingual dimension of posterior crown, 24, 25f
  - overview of, 17b
  - radiographic confirmation of accurate fit of implant-supported crown, 26-27, 27f
  - screw-retained crowns versus cemented crowns, 25-26, 26f

Implant dentistry

- evolutionary shifts in, 147-149
- growth of, 3
- implants, 147-148
- single crowns, 148-149

Implant placement

- in children

  - challenges associated with, 35-36, 42-43
  - complications of, 45-46
  - timing of, 44-45

- delayed, 18, 19f, 43
- factors affecting, 44b, 44-45
- immediate, 2f, 125f
- surgical guide versus freehand surgery for, 126-127
- too far facially, 169f
- trauma considerations, 44-45

Implant surgery

- freehand, 126-127
- restricted vertical space for surgical access during, effects on implant loading, 127, 128f, 128t

Implant-protected occlusion

- description of, 79, 98-99, 150, 174f
- occlusal contacts for, 99-101
- single-implant fracture and, 131-132, 132t

Implant-supported crowns. *See also* Crown(s).

- anterior, centering beneath the crown, 20
- fit of, radiographic confirmation of, 26-27, 27f
- horizontal distance for, 156
- incomplete seating of, 81
- infraocclusion of, 41t
- long-axis orientation of crown, 120
- occlusal forces on, 187
- occlusion of, 30, 30f
- remaking of. *See* Remaking, of implant-supported crowns.
- removal of, for treating open proximal contacts, 64

replacement of, 189  
splinting of, 18, 20f  
tactile sensibility of, 140

Inflammation, 10

Inraposition/infraocclusion  
cause and effect for, 48  
clinical implications of, 49  
description of, 37  
diagnosis of, 48  
gender and, 46–47  
illustration of, 5f, 38f–39f  
incidence of, 5t, 39, 40t–41t  
management of, 48–49  
measurement data for, 41t  
natural tooth located between two implants, 47–48  
in older patients, 39  
patient versus clinician awareness of, 47  
prevention of, 49  
quantification of, 37, 39  
remake of implant-supported crown because of, 184–185, 185f  
steps for minimizing, 48–49

Interarch occlusal forces, 63

Interproximal contact(s)  
adjustments to, 77  
for cemented crowns  
adjustments in, 80–81  
description of, 66  
closed, 56  
occlusal view of, 65f  
open, 55f, 55–56, 64f  
open mesial, 186f  
for screw-retained crowns  
adjustments in, 81  
description of, 29, 30f

Interproximal contact loss  
cause and effect of, 67  
clinical findings related to, 57–58  
definition of, 51–52  
diagnosis of, 67  
distal, 63  
early reporting of, 55  
frequency of, 57–58  
illustration of, 6f, 52f, 181f  
incidence of, 5t, 51–52, 53t–54t, 56, 58  
management of, 67  
with no visible interproximal space, 58  
occlusion and, 62, 63b  
peri-implant changes associated with, 56b  
prevention of, 67  
radiographic documentation of, 57f  
remake of implant-supported crown because of, 185, 186f  
single implant effects of, 56b, 56–57  
size of, 57–58  
steps for minimizing, 67  
stress waves effect on, 62  
vibration effects on, 62  
with visible interproximal space, 58–59

Interproximal open contact. See Interproximal contact loss.

Interproximal space  
direct measurement techniques for  
dental floss technique, 59  
leaf gauge technique, 60  
shim stock technique, 59–60, 60t  
indirect measurement techniques for, 60–61  
scanning techniques for, 60  
3D scanning and 3D digital superimposition techniques for, 60–61

Intra-arch occlusal forces, 63

IPO. See Implant-protected occlusion.

**L**

Leaf gauge technique, 60

Loss of crown retention  
cause and effect, 176  
cement selection considerations, 165t, 166  
for cemented crowns, 168t  
clinical implications of, 176  
diagnosis of, 176  
excess cement as cause of, 175, 175f  
factors contributing to, 168, 169b, 169f–171f  
illustration of, 7f  
incidence of, 5t, 164–168, 165t, 168t  
management of, 176  
mobility assessments, 172–173  
occlusal contact perception and, 173–174  
overview of, 163–164  
prevention of, 176  
remake of implant-supported crown because of, 188–189, 189f  
steps to minimize, 176  
zirconia implants, 5t, 164, 165t

Luting agents, 175

**M**

Mandibular molars  
abutment screw in, 94f  
first  
crown fracture, 143f  
implant position in, 22f, 119f  
occlusal screw access in, 21f  
screw-retained, 26f  
implant in  
fracture of, 125f  
immediate placement of, 125f  
immediately placed, 28f

second  
  implant crown, 87f  
  wear on, 25f

Mandibular second premolars, 24f

Maxillary canines  
  custom abutment for, 27f  
  implant on, 7f, 31f

Maxillary first molar implant, 123f

Maxillary first premolar implant, 182f

Maxillary incisors  
  central  
    avulsion of, 37f  
    implant in, 22f  
    single implant, 141f  
  crowns on, 185f  
  lateral  
    crowns placed on, 38f  
    implant crown, 101f, 181f

Maxillary second molars  
  crown fracture, 142f  
  immediate implant placement in furcal bone, 125f  
  zirconia crown on, 7f

Maxillary second premolars  
  single-tooth implant in, 61f

Maximal intercuspaton, 30, 30f, 61f, 101f, 130f, 174f

Mechanical torque devices  
  friction-style, 83  
  spring-style, 83  
  types of, 81b  
  variability of, 83

Mesial drift, 61–62

Mesiodistal adjustable crown, 66

Metal-ceramic crown  
  aging of, 184  
  fracture of, 142f  
  illustration of, 3f, 163f  
  porcelain veneer of, 182f

Metal-ceramic fixed partial dentures, 141

Monolithic crowns  
  chipping of, 146–149, 148t–149t, 154  
  materials for, 149

MTDs. See Mechanical torque devices.

**O**

Occlusal contacts  
  centric, 61f, 100, 153  
  eccentric. See Eccentric contacts.  
  maximum intercuspaton, 174f  
  perception of, 150, 173  
    for single-implant crowns, 99, 99f, 151

Occlusal devices, 63–64

Occlusal forces  
  abutment screw loosening caused by, 85  
  ceramic chipping and fracture caused by, 160  
  cuspal inclinations with, 23, 25f  
  interarch, 63  
  intra-arch, 63  
  single-implant fracture caused by, 118, 187  
  transfer of, 63

Occlusal guard, 18, 20f

Occlusal overload, 115, 132, 136

Occlusion. See also Infraposition/infraocclusion.  
  adjustments to, 104, 153  
  analysis of, 173  
  chair position effects on, 153  
  implant-protected. See Implant-protected occlusion.  
  interproximal contact loss and, 62, 63b  
  for single-implant crowns, 150

Older patients  
  facial growth in, 39  
  maxillary anterior teeth vertical changes in, 46

Open interproximal contacts, 55f, 55–56, 64f

Open proximal contacts. See also Interproximal contact loss.  
  assessment and measurement of, 58–61  
  clinical implications of, 67  
  treatments to close, 64–67

Oral examination, 11

Orthodontic treatment, 45

Osseointegration, 2, 9

Osseoperception, 132, 150

**P**

Parafunctional habits. See also Bruxism.  
  abutment screw loosening caused by, 85, 98  
  ceramic chipping and fracture caused by, 160  
  description of, 18, 20f, 23, 63  
  eccentric occlusal contacts affected by, 102  
  single-implant fracture caused by, 110

Parental pressure, 43

Passive tactile sensibility, 151–152

PCL. See Proximal contact loss.

PDL. See Periodontal ligament.

Pediatric patients. See Children.

Periodontal ligament, 98

Platform matching, 122

Platform switching, 122

Polyvinyl siloxane impression, 175

Porcelain veneer fracture/chipping. See Ceramic chipping and fracture.

Posterior crowns  
  cuspal inclination relative to torque, 117–118  
  eccentric contacts on, 101–102, 103f  
  faciolingual dimension of, narrowing of, 24, 25f

Posterior single implants  
in furcal bone, 28, 28f  
long axis of, aligned with opposing functional cusps, 21, 22f

Preload force, 84

Proprioception, 150–152, 173

Provisional cement, 26

Provisional cements, 166

Proximal contact loss. *See also* Interproximal contact loss.  
incidence of, 58  
parafunctional habits and, 63

Pubertal growth spurts, 43

**R**

Remaking, of implant-supported crowns  
abutment screw loosening and fracture as reason for, 186–187, 187f  
cause and effect, 190  
ceramic chipping and fracture as reason for, 187–188  
clinical implications of, 190  
complications leading to, 184–189  
diagnosis of, 190  
illustration of, 8f  
incidence of, 5t, 179, 180t  
infraposition/infraocclusion as reason for, 184–185, 185f  
interproximal contact loss as reason for, 185, 186f  
loss of crown retention as reason for, 188–189, 189f  
management of, 190  
overview of, 179–180  
prevention of, 190  
single-implant fracture as reason for, 187, 188f  
steps to minimize, 190

Resin-bonded prostheses, 43, 43f

**S**

Screw-retained crowns  
abutment screw access with, 90f–91f, 90–92  
cemented crowns versus, 25, 67  
crown-implant junction of, 104  
illustration of, 141f  
interproximal contacts with  
adjustments in, 81  
description of, 29, 30f  
management of, 67  
securing of, 79–80, 79f–80f

Screw-retained mandibular first molars, 26

Shim stock technique, 59–60, 60t, 100f

Single implants  
anterior, long-axis angulation of, 119  
antirotational features of, 75f  
biomechanics of. *See* Implant biomechanics.  
canines, 100–101

challenges with, 4, 5t  
complications associated with. *See* Complications.  
crowns, 180t, 180–181, 183  
design of, 116f, 116–117  
failure of, 9, 175f  
global market for, 76  
increased use of, 3–4  
indications for, 35  
interproximal contact loss effects on, 56b, 56–57  
long-axis angulation of, 118–121, 120f–121f  
occlusal scheme for, 98–99  
in pediatric patients, 35  
placement of. *See* Implant placement.  
posterior  
horizontal offset of, 122, 123f–124f  
long axis of, 21, 22f, 119–120  
premature placement of, 36  
prosthetic challenges for, 4, 5t  
survival rates for, 8–10, 9t  
tactile perception of, 173  
treatment planning for, 149

Single-implant contacts, 55

Single-implant crowns  
aging of, 184  
loss of retention, 166  
occlusal contacts for, 99, 99f, 151  
occlusion for, 150

Single-implant fracture  
anterior  
horizontal offset of, 122, 122f  
long-axis orientation of, 119  
biomechanical causes of, 113f  
bruxism as cause of, 110, 118f, 130–131  
cause and effect for, 134–135  
causes of, 111f  
clinical implications of, 136  
clinical repercussions of, 113  
diagnosis of, 134  
early indicators of, 115  
factors contributing to  
abutment-implant fit, 128–129  
adverse leverage prevented using surgical guide, 126–127, 127f  
apical offset, 126  
biomechanical, 117–128, 134  
bruxism, 130–131, 131f  
crown-to-implant ratio, 126, 127f, 136  
cuspal inclination, 117–118  
design flaws, 116f, 116–117, 136  
horizontal offset, 122, 122f–125f  
implant-protected occlusion, 131–132, 132t  
long-axis angulation of implant, 118–121, 120f–121f, 136  
manufacturing issues, 116–117  
materials issues, 116f–117f, 116–117

occlusal forces, 118, 187  
occlusal habits, 129–131  
overview of, 115, 115b  
physiologic function, 129–131  
restricted vertical space for surgical access effects on implant loading, 126–127, 127f  
illustration of, 7f, 188f  
implant replacement for, 114–115  
incidence of, 5t, 109–110, 111t–112t, 112–113, 114t, 134  
indicators of, 115  
last tooth in the arch at risk for, 133, 133f–134f, 154  
as late complication, 114, 136  
management of, 109, 114–115, 135  
occlusal overload as cause of, 115, 132, 136  
outcomes reporting for, 132  
overview of, 109  
parafunctional habits as cause of, 110  
posterior  
    horizontal offset of, 122, 123f–124f  
    long-axis orientation of, 119–120  
prevention of, 134–136, 135b  
prognosis for, 114–115  
remaking of implant-supported crown because of, 187, 188f  
survival affected by, 10  
timing of, 114  
trephine drill used to remove, 135f  
wide-diameter implants used to reduce risk of, 128, 129f

Spatial perception, 151  
Splinting  
    of adjacent implants, 18, 20f  
    of implant-supported crowns, 18, 20f

Spring-style devices, 83  
Stereognosis, 151  
Stress waves, 62  
Surgical guide, 19f

**T**

Tactile perception, 150  
Tactile sensibility, 132, 150–151, 173  
Technical complications, 10–11  
3D scanning and 3D digital superimposition techniques, 60–61  
Titanium abutments, 2f, 21f, 170f–171f, 189f  
Titanium implants, 5t  
Tooth extraction, 126f  
Tooth movement  
    distal movement, 61–62  
    mesial drift, 61–62

Torque  
    amount of, 85  
    posterior cuspal inclination relative to, 117–118  
    recommendations for, 77

Torque drivers, 84

Torque wrenches  
    beam and deflection, 81f, 82, 83f  
    broken-arm, 82, 82f–83f  
    dial indicator, 82f, 83  
    digital, 82f, 83  
    illustration of, 29f, 79f  
    torque amount with, 85  
    two-piece, 82, 82f–83f, 105  
    types of, 81b

Total occlusal convergence, 169f, 176

Trauma, 44–45

Two-piece torque wrenches, 82, 82f–83f, 105

**U**

Ultrasonic scalers, 96

**V**

Veneered crowns  
    chipping of, 146–149, 148t–149t, 154  
    materials for, 149

Vertical mouth opening, 18, 19f–20f, 129f

Vibration, 62

**W**

Wide-diameter implants, 128, 129f

Wrenches. *See* Torque wrenches.

**Y**

Young adults  
    implant failure versus success in, 47  
    maxillary anterior teeth vertical changes in, 46  
    removable partial denture in, 48

**Z**

Zinc oxide eugenol, 166, 175  
Zirconia abutments  
    cementation of, 166  
    custom, 167f  
    design of, 157  
    fracture of, 157–159, 157f–159f  
    illustration of, 2f, 157f, 167f  
    placement of, 157f

Zirconia coping, 141f  
Zirconia crown  
    illustration of, 159f  
    on maxillary second molar, 7f

Zirconia implants, 5t, 164, 165t

ZOE. *See* Zinc oxide eugenol.



# Contents

- 1 Seven Common Complications with Single Implants**
- 2 Principles of Implant Biomechanics**
- 3 *Complication #1: Infraposition/Infraocclusion***
- 4 *Complication #2: Interproximal Contact Loss***
- 5 *Complication #3: Abutment Screw Loosening and Fracture***
- 6 *Complication #4: Fracture of Single Implants***
- 7 *Complication #5: Ceramic Chipping and Fracture***
- 8 *Complication #6: Loss of Crown Retention***
- 9 *Complication #7: Remake of the Implant-Supported Crown***

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