Prosthetic complications of fixed dental prostheses supported by locking-taper implants: A retrospective study with a mean follow-up of 5 years.

Wen Mo Gao
Capital Medical University, School of Stomatology, Department of Stomatology
Wei Geng (gengwei717@aliyun.com)
Capital Medical University, School of Stomatology, Department of Stomatology
Chen Chen Luo
Capital Medical University, School of Stomatology, Department of Stomatology

Research Article

Keywords: prosthetic complications, implant restorations, implantology, locking-taper implants

Posted Date: February 25th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-228445/v1

Abstract

Background: Restoration with locking-taper implants is a widely used methodology. However, relatively few have examined conical connection systems like locking-taper implant systems. This study provides a retrospective study of locking-taper fixed restorations, mainly focused on prosthetic complications.

Methods: All patients who underwent conical connected implants from 2008–2010 were examined. Preparation of the implant sites was performed according to the standard procedures for the Bicon system. The bone healing took over 6 months, and the prosthetic procedure was initiated thereafter. Integrated abutment crowns or gold porcelain crowns were used, and the prosthesis type was a single crown or a fixed dental prosthesis. Once the crown was in place, its occlusion was thoroughly checked and adjusted, and then the crown was glazed or finely polished. The Kaplan-Meier method was used to calculate the cumulative complication-free rates for 5 and 10 years. Additionally, a Cox regression model was used to identify the factors that independently influenced the results. Implant survival and marginal bone loss were also investigated.

Results: A total of 392 patients who underwent 541 implants and 434 locking taper implant-based restorations from 2008–2010 were examined. The overall 5-year cumulative complication-free rate was 83.34%. The most common prosthetic complication was veneer chipping, with a frequency of 67.53%. According to the Cox regression model, the complication-free rate of integrated abutment crowns was significantly higher than gold porcelain crowns, molar regions was significantly higher than premolar regions, and females was significantly higher than males. Only three implant failures happened, and a mean marginal bone loss at 1- year, 5-year and 10- year was 0.25mm（95%CI）±0.12）, 0.40mm （95%CI） ±0.03）and 0.51mm（95%CI）±0.05）, respectively.

Conclusion: Veneer chipping was the most common complication with locking-taper implants supported fixed restorations. According to the result of Cox regression model, gold porcelain crowns are a protective factor relative to integrated abutment crowns, male sex is a protective factor relative to female sex, and premolar prosthetics are a protective factor relative to molar prosthetics. The long-term clinical effect of locking-taper implant is stable, and the implant success rate can meet the clinical needs. The bone tissue level around the implant can maintain long-term stability.

1. Background

Implant treatment is becoming an increasingly popular choice for patients. A study showed that the implant survival rate of implant supported fixed prostheses (single crowns) satisfactory [8]. However, complications arising from implant treatment are a bothersome issue for both doctors and patients [3, 8]. Additionally, it has been reported that screw failure is a large worry for clinicians and patients [26]. As shown by a systematic review, 12.7% of implant supported fixed prostheses are affected by loosening after an average of 5 years[13]. Screw loosening can be caused by inadequate tightening torque, fatigue, settling effect, micromotion, and excessive bending [28]. Thus, the appropriate preload is crucial for the

joint stability. Although screw loosening does not necessarily lead to prosthesis failure, it can allow plaque deposits to form that result from micro-gaps and micromotion [32, 36], and these deposits can lead to further biological complications, such as peri-implantitis or peri-implant mucositis. Accordingly, pure (screwless) implant systems, such as conical connection systems that are fixed by only friction, have been developed.

The implant-abutment interface of conical connection system is mostly Morse taper connected with cold-welding[21, 27], thus eliminating the prosthetic complications associated with screws [4]. The implant-abutment connections were usually less than 1.5° Morse tapers with an internal cone[27]. The abutment is fixed only by means of friction. Moreover, cold-welding provides a well-closed abutment-implant interface, which is conducive to plaque control and may reduce the incidence of biological complications [29]. Compared to screw-based systems, locking-taper connections are more stable and can better resist lateral and axial forces [22, 27].

Many studies and systematic reviews [14, 25]have assessed the complication rates of implant-supported fixed prostheses. However, most of these earlier studies focused on butt-joint screw- type implant-abutment connections systems, while relatively few have examined conical connection systems[17, 19]. The present study was a long-term retrospective study that aimed to assess the correlations between the cumulative prosthetic complication-free rate of fixed prostheses supported by locking-taper implants and various relevant factors, such as patient age, gender, prosthesis position, jaw position, restoration type (single crown (SC) or fixed partial prosthesis crown (FDP)), and the prosthetic materials that were used. MBL and implant survival rate were also investigated.

2. Methods

2.1 Study design and sample

All patients who were referred to the Beijing Stomatological Hospital during 2000–2010 and received at least one Bicon (Type of implant type, Bicon, Boston, MA, US) implant were enrolled in the study. This article is written using a statement from STROBE (Strengthening the Reporting of Observational studies in Epidemiology) as closely as possible. All procedures were performed in accordance with relevant guidelines. The informed consent was obtained from all the participants enrolled in the present study.

The exclusion criteria were as follows:

1. Patients for whom the implant failed in regard to osseointegration before the prosthetic procedures;
2. Patients with implants supported over dentures;
3. Patients whose medical record cannot provide sufficient information (specific restoration materials);
4. Patients with CAD-CAM zircon or monochrome porcelain crowns;
5. Patients for whom a guided bone regeneration (GBR) procedure was used.

6. Patients for whom a sinus floor elevation procedure was used.

The relevant factors were that were considered were (age> 60 years or 18 years ≤age< 60 years), gender, implant position (anterior, premolar, or molar region), implant location (maxilla or mandible), prosthesis type (single crowns(SCs) or fixed dental prosthesis (FDP)), and restoration material (integrated abutment crowns(IACs) or gold alloy porcelain crowns(GPCs)). Information was collected from the patients' medical records and disaggregated based on the relevant factors to identify those that had an impact on the incidence rate of prosthetic complications. Specific definitions of the complications are presented in Table 4. Both IACs and GPCs are most commonly used at our hospital, while monochrome porcelain and zircon crowns are seldom used. Therefore, the latter two types of crowns were not included in the study. Since the present study mainly focused on the prosthetic complications, the implants failed before prosthetic procedures started were excluded. Implants that had failed osseointegration, i.e., within 6 months of the implant operation, were excluded. In order to make the marginal bone loss (MBL) more comparable, patients for whom a sinus floor elevation procedure and a guided bone regeneration (GBR) procedure was used were excluded. These two types of patients are very few. Alternatives like short implant and changing prosthetic design are more commonly considered.

2.2 Surgical and restorative procedures

All implants were Bicon (Type of implant type, Bicon, Boston, MA, US) America implants. The implant-abutment connections were 1.5° Morse tapers with an internal cone. Preparation of the implant sites was performed according to the standard procedures for the Bicon system. The bone healing took over 6 months, and the prosthetic procedure was initiated thereafter. All the impressions were taken using polyether silicone rubber (Type of rubber type, 3M, St. Paul, MN, US). IACs or GPCs were used, and the prosthesis type was an SC (single crown) or an FDP (fixed dental prosthesis). Integrated abutment crowns (IACs) are a typical and fully retrievable type of restoration that is supported by locking-taper implants. IACs are metal-resin crowns made from a titanium base and a composite resin veneer of Ceramage (Type of veneer resin, SHOFU, JP). Ceramage(Type of veneer resin, SHOFU, JP) is a fiber-reinforced composite resin with filler particles that has a higher strength than conventional resin [16]. The GPCs were cemented with glass ionomer cement. Once the crown was in place, its occlusion was thoroughly checked and adjusted, and then the crown was glazed (GPCs) or finely polished (IACs).

2.3 Clinical and radiographic examination

This study focused on prosthetic complications, including veneer chipping/fracture, abutment loosening/fracture, and restoration decementation. These complications were recorded as endpoint events. Biological complications were not examined in the present study. Implant failures were counted in this study. Implant failures in this study were defined as the failures happened after prosthetic loading, other failures happened before prosthetic loading were not included. Implant failures in this study include peri-implantitis, progressive bone loss and implant body fracture.

Intraoral periapical radiographs were taken for each implant at 1-, 5- and 10- year follow-up examination time respectively for comparative analysis and measurements. Distance from the most coronal bone to the margin of implant neck were measured. In order to eliminate the impact of the distortion of images, the distance was calculated with the ratio of the implant length measured on the radiograph to the actual implant length. Mesial and distal distances were measured for each implant, and the average of the two were considered as the final MBL. All the measurements were taken by the same independent observer.

2.4 Data management and statistics

A database was prepared using Microsoft Excel. The populations of the different variable groups were assessed, and the data were then transferred to GraphPad Prism (version 7.0) for statistical analysis. Kaplan-Meier estimators were used to obtain survival curves (restoration based), from which the cumulative complication-free rates were calculated (CI = 95%). Log-rank and Gehan-Breslow-Wilcoxon tests were used to assess whether there were significant differences in the survival curves between the different groups ($p < 0.05$ represented a significant difference). In addition, implant failures and MBL were also investigated.

Based on the statistical results, the factors that had an impact on prosthetic complications were identified. After single-factor analysis was performed, multifactor analysis using a Cox regression model (SPSS version 23.0) was used to identify the factors that independently influenced the results. Factors with a p value<0.1 were included in the Cox regression model.

3. Results

3.1 Preliminary statistical results

A total of 392 patients who had at least one Bicon implant installed between January 2008 and January 2010, including a total of 541 implants and 434 restorations (201 for male patients and 233 for female patients), were included in the study. The average age of the patients was 43.07 years (restoration-based). The variables considered in the present study were the material (IACs versus GPCs), position (the posterior region, premolar region, and molar region), location (the maxilla versus mandible), age (age> 60 years versus 18 years age < 60 years), gender (male versus female), and prosthesis type (SCs versus FDPs). The patient distribution is shown in Table 1.

The current work was a long-term retrospective clinical study with an average follow-up of 5 years. The complication distribution by time is shown in Table 3. Between 2008 and 2010, 77 of the 434 restorations were affected by prosthetic complications. The complications that were taken into account in the present study were veneer chipping/fracture, abutment loosening/fracture and decementation. Other mechanic complications, such as implant fracture, were not included since no implant fractures occurred. The most common prosthetic complication was veneer chipping (52), with a frequency of 67.53%, followed by decementation (17) (which occurred in only GPC prostheses), with a frequency of 22.07%. Only one abutment fracture occurred in the 3rd year after the prosthesis placement. The complication frequencies

are presented in Figure 1. Most prostheses were located in the molar region, followed by the premolar region, and only a few were located in the anterior region. The position frequencies are shown in Figure 2. A total of 3 implant failures happened in 3 patients respectively, details were shown in table 5. MBL at 1-, 5- and 10-follow up were shown in table 6.

3.2 Univariate survival analysis

The overall prosthesis survival curve is presented in Figure 3. The overall 5-year cumulative complication-free rate was 83.84%, while the 10-year rate was 67.48%. The Kaplan-Meier method was used to calculate the cumulative survival rates (complication-free rates) and to create survival curves. Log-rank and the Gehan-Breslow-Wilcoxon tests were used to identify significant differences between the groups.

The five-year and ten-year cumulative complication-free rate was shown in table 2. Significant differences in the survival curves were observed in the material and position groups ($p < 0.05$). Conversely, no significant differences were observed in the gender, age, location, or prosthesis-type groups ($p > 0.05$). There were significant differences in the early phase for the position groups (Gehan-Breslow-Wilcoxon test: $p = 0.02$). For the location groups, prostheses in the mandibles showed a slightly higher complication incidence rate than those in the maxilla ($p = 0.09$). Furthermore, the female group had a slightly higher complication rate than the male group ($p = 0.05$), and the older group had a bit higher complication rate than the younger group ($p = 0.33$). However, these differences were not statistically significant. No notable differences were observed between these groups ($p = 0.67$). Nevertheless, these factors may influence each other. Multivariate analysis with Cox regression was used to identify the factors that independently influenced the results. To avoid the omission of possible influential factors, factors with a p value<0.1 were included in the Cox regression model, including gender (p=0.0526), material (p=0.04), implant position (p=0.04) and location (p=0.09) (Table 3).

3.2 Multivariate regression analysis

Multivariate regression analysis with Cox regression was used to examine the influential factors, including gender, material, implant position and location. The results are shown in table 7. After multivariate regression analysis, the results showed that material, gender and tooth position were independent factors affecting survival time. According to the HR value, the material was an independent protective factor, indicating that IACs had a longer survival time than GPCs (p=0.043, HR=0.615 (95% CI [0.385;0.984])). Gender was an independent risk factor, and the female survival time was shorter than the male survival time (p=0.041, HR=1.627 (95% CI [1.021;2.592])). The survival time of premolars was longer than that of molars (p=0.024, HR=0.375 (95% CI [0.160;0.879])). The other indicators did not independently affect the survival time.

4. Discussion

4.1 Preliminary Results

Presently, implant clinical outcomes are satisfactory, with a survival rate of up to 95% [5 10]. However, prosthetic complications for implant-supported fixed prostheses still trouble clinicians and patients. The term “prosthetic complications” is a collective term that covers mechanical and technical complications [9]. These mechanical and technical complications include abutment loosening/fracture, screw loosening/fracture, veneer chipping, and decementation.

A previous 5-year systematic review of the clinical outcomes of fixed complete dentures supported by implants showed that the survival rate of the implants was satisfactory but that the prosthetic complication rate was rather high [23]. Veneer chipping was the most common prosthetic complication. Another clinical study divided veneer chipping into three different types according to its severity. [30] Veneer chipping ranges widely in severity, which may sometimes lead to loss of masticatory function. Other studies have also shown that the complication rates of implant-supported fixed prostheses have significantly increased over time [35 3]. However, most of these earlier studies focused on screw-connected systems, while relatively few studies have examined conical connected systems.

In most clinical studies regarding locking-taper systems, most of the prostheses that were examined were porcelain-fused-metal-fixed prosthetics, most commonly GPCs [18 17 6]. Compared to the number of studies on porcelain-fused-metal-fixed prostheses, far fewer studies have focused on metal-acrylic prostheses, and most of these studies have mainly focused on complete dentures [12 33]. The conclusion that veneer chipping is the most common prosthetic complication associated with titanium-acrylic complete dentures have been confirmed in other studies [12, 24, 33].

In the current study, prosthetic complications, such as abutment loosening and abutment fracture, occurred much less frequently than technical complications such as veneer chipping or decementation. This prosthetic complication distribution is similar to that observed in a previous retrospective study, in which only two abutment fractures and one case of abutment loosening were observed in the 80 subjects [4].

4.2 Implant failures and MBL

Screw-connected implant systems can have micro-gaps of about 40~100 μm at the interface between implant and abutment [7, 34], which will accumulate plaques and increase the probability of periimplantitis[32]. Locking-taper implant systems can greatly reduce the micro-gaps (1~3μm)compared to the former, thus may decrease the probability of periimplantitis [29]. The implant survival in this study is satisfactory. Several other studies confirm that Among all the patients who met the inclusion criteria, only three implant failure occurred. All the three failed implants were periimplantitis which supported single crown prostheses. Although periimplantitis occurred, the morbidity was greatly reduced compared to screw-connected implant systems [1, 8, 10], which may ascribe to the minute micro-gap of locking-taper implant systems. Another systematic review comes to the same conclusion[28].

The present study revealed a stable MBL, at 1- year, 5-year and 10- year, respectively. All the periapical radiographs in this study were measured by the same clinician who received professional training under the same conditions. In order to minimize the impact of image distortion, MBL was calculated by converting the actual measured implant length to the actual implant length. Due to the high dropouts of the present study, the 10-year MBL are for reference only. A long term retrospective study showed a mean MBL of locking-taper systems at 1- year（0.33mm（95%CI）±0.01） , 5- year（0.45mm （95%CI）±0.02）and 10-year（0.78mm（95%CI）±0.06）, respectively [19]. Another clinical study up to 12 years revealed a mean MBL at 1-year（0.34mm（95%CI）±0.27）, 6-year（0.46mm （95%CI）±0.29）and 12-year（0.83mm（95%CI）±0.41）, respectively[5]. The results of MBL of the present study are similar to those of previous studies, which indicates that the long-term clinical outcome of locking-taper implant is satisfactory.

4.3 Multivariate regression analysis

The results of the multifactor analysis are shown in Table 6.According to a previous study, the use of Ceramage can reduce the risk of veneer chipping in comparison to that of conventional metal-based porcelain crowns since its elastic modulus is close to that of natural teeth [11]. However, in the present study, compared with the GPCs, the survival time of the IAC crowns was significantly shorter, which was consistent with the results of the univariate analysis. The interfacial adhesion of titanium and acrylic is mainly due to physical adhesion, and some chemical adhesion is provided by coupling agents. These types of adhesion are weaker than the chemical adhesion between gold alloy and porcelain. We believe that these different interfacial bonding forces are the root cause of the results presented in this study. Similarly, a recently published meta-analysis reported that the chipping rate of porcelain-fused-metal-fixed prostheses is 9%, which is much lower than that of metal-resin prostheses (27%)[2]. However, prosthetic complications, such as abutment loosening and abutment fracture, were presented by GPCs. These results may be the result of the cushioning effect of the resin, which accommodates some of the mechanical force that is applied to implant components. IACs have unique advantages. The resin exhibits excellent stress resistance, reducing damage to the implant [20].The bonding of IACs is completed outside of the mouth, reducing the potential irritation of the periodontal tissue by the adhesive. Additionally, the fact that IACs can be repaired in the mouth by clinicians can greatly reduce procedure times. In contrast, the repair of metal-based porcelain crowns, such as alternatives such as GPCs, can be difficult. The strength of the metal base can be reduced by repeated firings, during which tiny cracks may arise [31].

After removing the confounding factors, there was no significant difference in the survival time of the prosthesis in the maxilla and mandible, and the difference between the two groups was further narrowed, which may indicate that the effect of the jawbone density was not as large as expected. The survival time of the prostheses in the premolar area was significantly longer than that in the molar area. In both the maxilla and mandible, the molar region presented higher complication rates than that of the premolar region, and a significant difference was observed (log-rank test $p < 0.05$). Too few mandibular anterior prostheses were performed to assess the cumulative complication-free rate. Similarly, it has been

previously reported that prosthetic complications occur more frequently in the molar region because of the mechanical force conditions in that area [15]. Because the number of cases in the anterior teeth area was too small, the results of the anterior tooth area in this study were not statistically significant. The results of this study are similar to those of previous studies. A study have showed that the incidence of complications in the anterior tooth area was slightly lower than that in the posterior tooth area [18]. This may be related to the inclusion of both biological and repair complications in the study. In addition, all the restorations in this study were metal fused porcelain crowns, which may have further eliminated the gap in the survival time between the different tooth positions due to its high strength, as demonstrated in the present study. In contrast to the univariate analysis, there was a significant difference in survival time between the gender groups in the multivariate analysis. This may be because females typically exhibit better adherence than males and return more quickly for advice than men when complications occur, or the result may have been affected by other influencing factors.

This study was a retrospective survival analysis, and as such, the results will inevitably deviate from those of prospective experiments. There was not a control group for the distribution of implants and prostheses, and for some variables groups, the differences were rather significant, such as those between the restoration type (FDPs: SCs = 107: 327), material (IACs: GPCs= 139:295), and age (> 60 years:< 60 years = 72: 362). These differences may have impacted the statistical results to a certain degree. The ways that the two influential factors that were discussed above impact other aspects, such as biological complications and the survival rate, will require further prospective and long-term follow-up studies.

5. Conclusions

Based on this study, it can be concluded that veneer chipping is the most common prosthetic complication for both IACs and GPCs that are supported by locking-taper implants. Over time, the prosthetic complication rate increases significantly, and the incidence of complications for IACs is significantly higher than that for GPCs. This study is an analysis of the prosthetic complications of locking-taper implants and has verified that there are significant differences between the different prosthetic materials, different placement positions and genders. Age, location, and prosthesis type are not determinants of prosthetic complications. Besides, the long-term clinical effect of locking-taper implant is stable, and the implant success rate can meet the clinical needs. The bone tissue level around the implant can maintain long-term stability.

Declarations

ACKNOWLEDGEMENTS:

The authors kindly thank American Journal Experts (AJE) for professional English editing.

FUNDING:

This work was supported by the National Natural Science Foundation of China (Grant No. 62071313).

Author's Contributions:

Wen mo Gao completed the data collection. Chen chen Luo and Wei Geng provided cases. Wen mo Gao and Wei Geng designed the observational clinical experiment scheme. Wen mo Gao undertook figure editing and drafted the manuscript. Chen chen Luo and Wei Geng reviewed the manuscript.

Ethics declarations:

Ethics approval and consent to participate:

The present study was approved by the Ethics Committee (Scientific Research/Technical Branch) of Beijing Stomatological Hospital affiliated with Capital Medical University (approval number CMUSH-IRB-KJ-PJ-2019-12). The informed consent was obtained from all the participants enrolled in the present study.

Consent to publish

Not Applicable.

Competing interests

The authors do not have any potential conflicts of interest to indicate.

Availability of data and materials

The dataset used and/or analyzed during the current study available from the corresponding author on reasonable request.

References

1 M. Aglietta, V. I. Siciliano, M. Zwahlen, U. Bragger, B. E. Pjetursson, N. P. Lang, and G. E. Salvi, 'A Systematic Review of the Survival and Complication Rates of Implant Supported Fixed Dental Prostheses with Cantilever Extensions after an Observation Period of at Least 5 Years', *Clin Oral Implants Res,* 20 (2009), 441-51.

2 Aimen Bagegni ; Samir Abou-Ayash ; Wael Att, 'Effect of Prosthetic Material on the Outcome of Dental Implants Supporting Implant-Supported Dentures: A Meta Analysis', *Clinical Oral Implants Research,* 28 (2017).

3 U. Bragger, I. Karoussis, R. Persson, B. Pjetursson, G. Salvi, and N. Lang, 'Technical and Biological Complications/Failures with Single Crowns and Fixed Partial Dentures on Implants: A 10-Year Prospective Cohort Study', *Clin Oral Implants Res,* 16 (2005), 326-34.

4 MD Carlo Mangano, DDS1/Enrico G. Bartolucci, MD, DDS, MS2, 'Single Tooth Replacement by Morse Taper Connection Implants: A Retrospective Study of 80 Implants', *The International journal of oral*

& maxillofacial implants, 16 (2001).

5 P. G. Coelho, P. Sudack, M. Suzuki, K. S. Kurtz, G. E. Romanos, and N. R. Silva, 'In Vitro Evaluation of the Implant Abutment Connection Sealing Capability of Different Implant Systems', *J Oral Rehabil,* 35 (2008), 917-24.

6 Fg.Mangano, M.Colombo, and C. Mangano, 'Clinical Evaluation of 762 Single-Tooth, Locking-Taper Implants: A Prospective Study with 1- to 12-Years of Follow-Up', *Journal of Dentistry and Oral Care Medicine* (2016).

7 DDS Francisco F. Todescan, MS1/Francisco E. Pustiglioni, DDS, MS2/Ana V. Imbronito, DDS, MS1/ Tomas Albrektsson, MD, PhD, Odhc3/Marco Gioso, MD, MS, DVM, DDS4, 'Influence of the Microgap in the Peri-Implant Hard and Soft Tissues: A Histomorphometric Study in Dogs', *INT J ORAL MAXILLOFAC IMPLANTS* (2002), 5.

8 DDS Germana De Villa Camargos, MS1/Célio Jesus do Prado, DDS, MS, PhD2/Flavio Domingues das Neves, DDS, MS, PhD2/Ivete Aparecida de Mattias Sartori, DDS, MS, PhD3, 'Clinical Outcomes of Single Dental Implants with External Connections: Results after 2 to 13 Years', *The International Journal of Oral & Maxillofacial Implants,* 27 (2012).

9 PD Giovanni E. Salvi, Dr Med Dent1/Urs Brägger, Prof Dr Med Dent2, 'Mechanical and Technical Risks in Implant Therapy', *The International journal of oral & maxillofacial implants* (2009).

10 Daniel S Thoma hBjarni Elvar Pjetursson, Ronald Jung,Anja Zembic, 'A Systematic Review of the Survival and Complication Rates of Implant-Supported Fixed Dental Prostheses (Fdps) after a Mean Observation Period of at Least 5 Years', *Clinical Oral Implants Research* 23 (2012).

11 PhDaF.LutzMD I.KrejciDMD, DMD, PhDbL.GautschiDMDc, 'Wear and Marginal Adaptation of Composite Resin Inlays', *Journal of Prosthetic Dentistry,* 72 (1994).

12 Emilio Jiménez-Castellanos Javier Ventura, José Romero,Francisco Francisco, 'Tooth Fractures in Fixed Full-Arch Implant-Supported Acrylic Resin Prostheses: A Retrospective Clinical Study', *The International journal of prosthodontics* 161 (2016).

13 R. E. Jung, B. E. Pjetursson, R. Glauser, A. Zembic, M. Zwahlen, and N. P. Lang, 'A Systematic Review of the 5-Year Survival and Complication Rates of Implant-Supported Single Crowns', *Clin Oral Implants Res,* 19 (2008), 119-30.

14 R. E. Jung, A. Zembic, B. E. Pjetursson, M. Zwahlen, and D. S. Thoma, 'Systematic Review of the Survival Rate and the Incidence of Biological, Technical, and Aesthetic Complications of Single Crowns on Implants Reported in Longitudinal Studies with a Mean Follow-up of 5 Years', *Clin Oral Implants Res,* 23 Suppl 6 (2012), 2-21.

15 CD Kopp, 'Branemark Osseointegration. Prognosis and Treatment Rationale.', *Dental Clinics of North America,* 33 (1989).

16 T Trinkner L Rosenthal, C Pescatore, 'A New System for Posterior Restorations: A Combination of Ceramic Optimized Polymer and Fiber-Reinforced Composite', *Practical periodontics and aesthetic dentistry : PPAD,* 9 (1997).

17 C. Mangano, F. Iaculli, A. Piattelli, and F. Mangano, 'Fixed Restorations Supported by Morse-Taper Connection Implants: A Retrospective Clinical Study with 10-20 Years of Follow-Up', *Clin Oral Implants Res,* 26 (2015), 1229-36.

18 F. Mangano, A. G. Lucchina, M. Brucoli, M. Migliario, C. Mortellaro, and C. Mangano, 'Prosthetic Complications Affecting Single-Tooth Morse-Taper Connection Implants', *J Craniofac Surg,* 29 (2018), 2255-62.

19 F. Mangano, A. Macchi, A. Caprioglio, R. L. Sammons, A. Piattelli, and C. Mangano, 'Survival and Complication Rates of Fixed Restorations Supported by Locking-Taper Implants: A Prospective Study with 1 to 10 Years of Follow-Up', *J Prosthodont,* 23 (2014), 434-44.

20 Rifkin R McLaren EA, Devaud V, 'Considerations in the Use of Polymer and Fiber-Based Indirect Restorative Materials', *Pract Periodontics Aesthet Dent,* 11 (1999).

21 Michael R. Norton, 'Assessment of Cold Welding Properties of the Internal Conical Interface of Two Commercially Available Implant Systems', 81 (1999), 159.

22 MR Norton, 'An in Vitro Evaluation of the Strength of an Internal Conical Interface Compared to a Butt Joint Interface in Implant Design.', *Clinical Oral Implants Research,* 8 (2010).

23 DDS Panos Papaspyridakos, MS1/Chun-Jung Chen, DDS2/Sung-Kiang Chuang, DMD, MD, DMSc3/Hans-Peter Weber, DMD, Dr Med Dent4/German O. Gallucci, DMD, Dr Med Dent5, 'A Systematic Review of Biologic and Technical Complications with Fixed Implant Rehabilitations for Edentulous Patients', *The International journal of oral & maxillofacial implants,* 27 (2012).

24 G. Priest, J. Smith, and M. G. Wilson, 'Implant Survival and Prosthetic Complications of Mandibular Metal-Acrylic Resin Implant Complete Fixed Dental Prostheses', *J Prosthet Dent,* 111 (2014), 466-75.

25 E. Romeo, and S. Storelli, 'Systematic Review of the Survival Rate and the Biological, Technical, and Aesthetic Complications of Fixed Dental Prostheses with Cantilevers on Implants Reported in Longitudinal Studies with a Mean of 5 Years Follow-Up', *Clin Oral Implants Res,* 23 Suppl 6 (2012), 39-49.

26 R. Sadid-Zadeh, A. Kutkut, and H. Kim, 'Prosthetic Failure in Implant Dentistry', *Dent Clin North Am,* 59 (2015), 195-214.

27 G. Sannino, and A. Barlattani, 'Mechanical Evaluation of an Implant-Abutment Self-Locking Taper Connection: Finite Element Analysis and Experimental Tests', *Int J Oral Maxillofac Implants,* 28 (2013), e17-26.

28 C. M. Schmitt, G. Nogueira-Filho, H. C. Tenenbaum, J. Y. Lai, C. Brito, H. Doring, and J. Nonhoff, 'Performance of Conical Abutment (Morse Taper) Connection Implants: A Systematic Review', *J Biomed Mater Res A,* 102 (2014), 552-74.

29 DMD1/Martha Warbington Serge Dibart, MS2/Ming Fan Su, DMD MS3/Ziedonis Skobe, PhD4, 'In Vitro Evaluation of the Implant-Abutment Bacterial Seal:The Locking Taper System', *The International Journal of Oral & Maxillofacial Implants,* 20 (2005), 732-37.

30 J. Y. Shi, X. M. Zhang, S. C. Qiao, S. J. Qian, J. J. Mo, and H. C. Lai, 'Hardware Complications and Failure of Three-Unit Zirconia-Based and Porcelain-Fused-Metal Implant-Supported Fixed Dental Prostheses: A Retrospective Cohort Study with up to 8 Years', *Clin Oral Implants Res,* 28 (2017), 571-75.

31 Wang Zhongyi Sun Ying, Wang Baocheng, 'The Influence of Repeated Firings on the Remained Porcelain Rate', *J Pract Stomatol,* 18 (2002).

32 M. Tallarico, L. Canullo, M. Caneva, and M. Ozcan, 'Microbial Colonization at the Implant-Abutment Interface and Its Possible Influence on Periimplantitis: A Systematic Review and Meta-Analysis', *J Prosthodont Res,* 61 (2017), 233-41.

33 DDS1/Haralampos Petridis Theodora Bozini, DDS, MSc, PhD2/Konstantinos Tzanas, BS, MSc3/Pavlos Garefis, DDS, PhD4, 'A Meta-Analysis of Prosthodontic Complication Rates of Implant-Supported Fixed Dental Prostheses in Edentulous Patients after an Observation Period of at Least 5 Years', *The International Journal of Oral & Maxillofacial Implants,* 26 (2011).

34 D. Weng, M. J. Nagata, M. Bell, A. F. Bosco, L. G. de Melo, and E. J. Richter, 'Influence of Microgap Location and Configuration on the Periimplant Bone Morphology in Submerged Implants. An Experimental Study in Dogs', *Clin Oral Implants Res,* 19 (2008), 1141-7.

35 Buser D Wittneben JG1, Salvi GE, Bürgin W, Hicklin S, Brägger U., 'Complication and Failure Rates with Implant-Supported Fixed Dental Prostheses and Single Crowns: A 10-Year Retrospective Study.', *Clinical Implant Dentistry Related Research,* 16 (2014).

36 David C Yuya S 'Implant-Abutment Connections: A Review of Biologic Consequences and Peri-Implantitis Implications', *The International Journal of Oral & Maxillofacial Implants,* 32(6):1296-1307 (2017).

Tables

Study variables			
		N	%
Gender	Male	201	46.31%
	Female	233	53.67%
Age	age≥60	72	16.59%
	18≤age<60	362	83.41%
Material	IAC	139	32.03%
	MC	295	67.97%
Type	SCs	327	75.35%
	FDPs	107	24.65%
Implant position	Anterior region	32	7.37%
	Premolar region	94	21.66%
	Molar region	308	70.97%
Implant location	Maxilla	209	48.16%
	Mandible	225	51.84%

Table.1 Study variables

The relevant factors were considered to be age (> 60 years or < 60 years), gender, implant position (anterior, premolar, or molar region), implant location (maxilla or mandible), prosthesis type (SC or FPPC), and restoration material (IAC or GPC). Distribution by different factors are shown in table.1.

Study Variables		Kaplan-Meier		Log-Rank Test		Gehan-Breslow-Wilcoxon test	
		5y	10y	Chi-square	P-value	Chi-square	P-value
Gender	Male	87.0%	73.0%	3.758	0.0526	3.358	0.07
	Female	80.87%	64.05%				
Age	≥60	76.23%	67.47%	0.946	0.33	1.235	0.27
	<60	85.03%	67.28				
Material	IAC	79.49%	53.06%	4.356	0.04	3.283	0.07
	GPC	85.04%	73.31%				
Type	SCs	84.01%	54.70%	0.181	0.67	0.215	0.64
	FPPs	83.53%	75.27%				
Implant position	Anterior region	85.02%	77.94%	6.703	0.04	7.542	0.02
	Premolar region	93.17%	85.51%				
	Molar region	81.27%	64.22%				
Implant location	Maxilla	87.38%	78.20%	2.936	0.09	2.073	0.15
	Mandible	80.20%	62.00%				
Total		83.84%	67.48%			-	

Table.2 Cumulative complication-free rates and curve comparison

Cumulative complication-free rates and statistical features are shown as above. The overall 5-year cumulative "complication-free" rate is 83.84%, while the 10-year rate is 67.48%. Significant differences are observed in material and position groups.

Complication	≤2years	2 ~5years	5year	total
Veneer chipping	17	19	15	52
Abutment loosening	0	2	5	7
Abutment fracture	0	1	0	1
Crown loosening /shedding	6	8	3	17

Table.3 Total prosthetic complications

Complication distribution by time is shown in table 4. Totally 78 of 451 prostheses suffered from prosthetic complications. Two single IACs suffered from veneer chipping within 3 months, and these cases are counted as early restoration failures. Specific statistics are shown as above.

Prosthetic complications	Definition
Veneer chipping	Veneer chipping or the fracture of IACs or GPCs, metal base exposed or not
Abutment loosening	Loosening that occurred in implant abutment interface, not in abutment-restoration interface
Abutment fracture	Fracture on the abutments, including cracks or complete fracture
Crown decementation	Decementation in GPCs

Table.4 Definition of the complications

This study focused mechanical complications, including veneer chipping/fracture, abutment loosening/fracture, and restoration decementation. Specific definitions of the complications are presented in table 4.

Gender	Age	Site	Time of failure(after prosthetic loading)	Type of failure
M	56	36	2 years	Peri-implantitis
M	49	26	1 year	Peri-implantitis
F	52	47	4 years	Peri-implantitis

Table.5 Failed implants

A total of 3 implant failures happened in 3 patients respectively, details were shown in table 6. All the 3 implants failed in 5 years after loading.

Year	Mean	SD	Median	CI(95%)
1	0.25	0.25	0.24	0.13-0.37
5	0.40	0.29	0.41	0.37-0.43
10	0.51	0.30	0.52	0.46-0.56

Table.6 Marginal bone loss disaggregated by time

a mean MBL at 1- year, 5-year and 10- year was 0.25mm（95%CI：±0.12）, 0.40mm （95%CI：±0.03） and 0.51mm（95%CI：±0.05）, respectively. The bone tissue level around the implant can maintain long-term stability.

Influencing factors	*B*	*SE*	*Wald*	*P*	*HR*	*HR 95% CI*
Material	-0.486	0.240	4.106	0.043	0.615	0.385-0.984
Location	0.184	0.244	0.565	0.452	1.201	0.745-1.939
Gender	0.487	0.238	4.192	0.041	1.627	1.021-2.592
Position						
Molar region			5.098	0.078		
Anterior region	-0.08	0.476	0.028	0.867	0.923	0.363-2.348
Premolar region	-0.98	0.435	5.09	0.024	0.375	0.160-0.879

Table.7 Cox regression model of the four influencing factors

Multivariate regression analysis with Cox regression was used to examine the influential factors, including gender, material, implant position and location. After multivariate regression analysis, the results showed that material, gender and tooth position were independent factors affecting survival time.

Figures

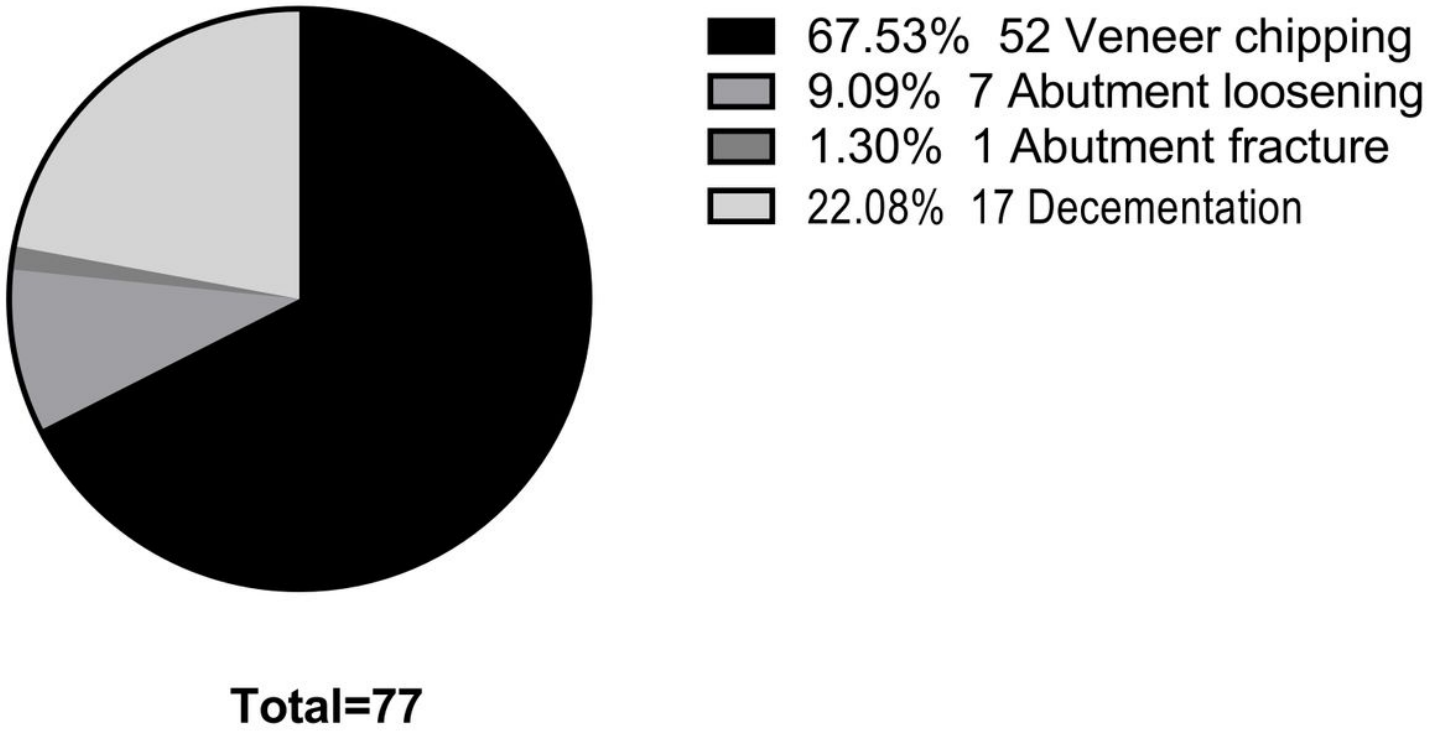

Figure 1

Prosthetic complications distribution There are totally 77 prostheses suffered from the prosthetic complications. The most common mechanical complication is veneer chipping (52), followed by decementation (17) (which only occurred in GPCs). The specific complication frequencies are presented in Figure 1.

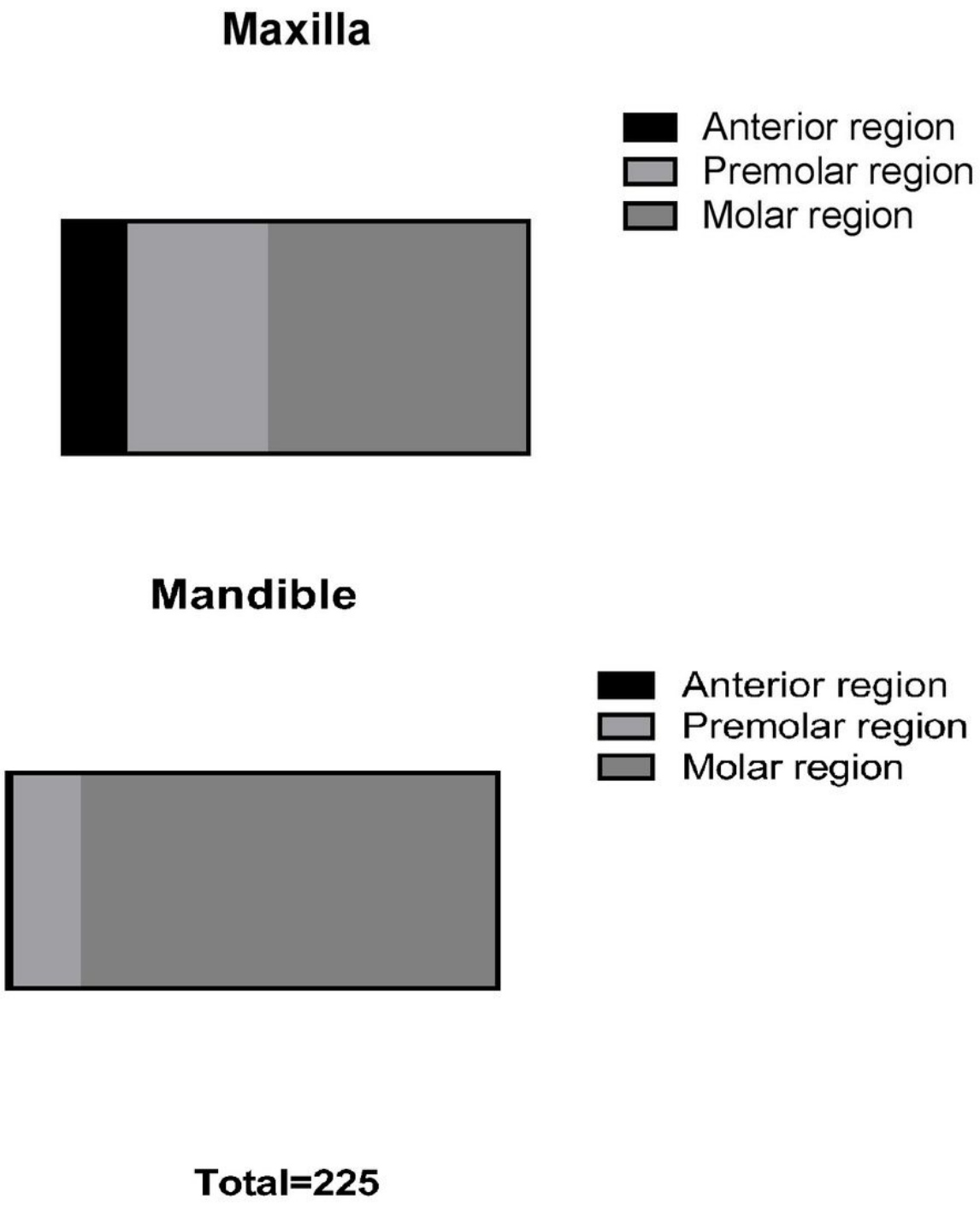

Figure 2

Implant distribution by position

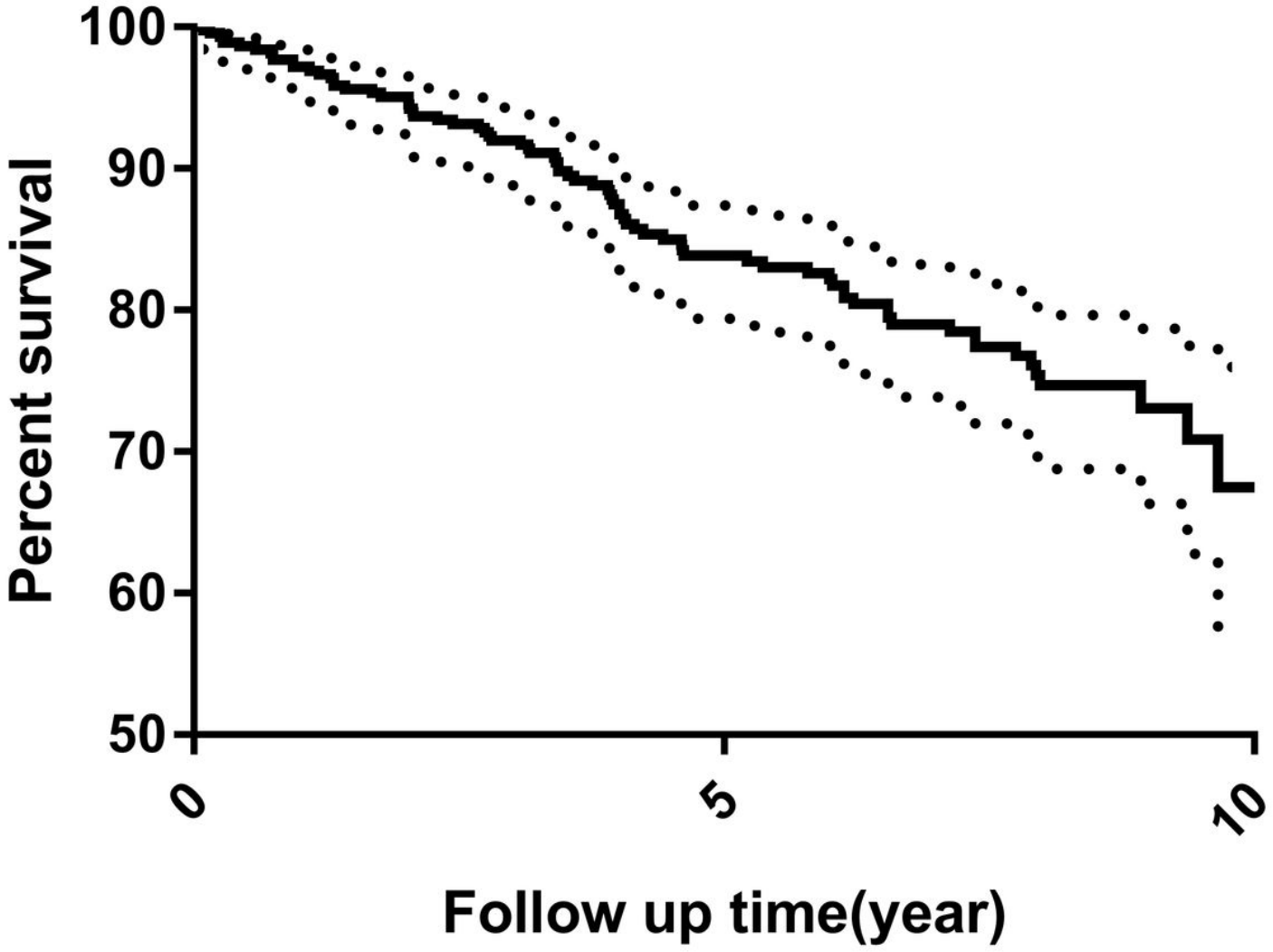

Figure 3

Mechanical complication-free survival curve of all restorations