Could Age at Surgery Be Associated with Early Mortality After Implant Surgery? A Retrospective Study of 3,877 Edentulous Patients

Torsten Jemt, DDS, PhD1/Jan Kowar, DDS, PhD2/Victoria Stenport, DDS, PhD1

Purpose: Knowledge of the early mortality patterns in edentulous implant patients is limited. This study aimed to report patient mortality within the first year after surgery and compare the cause of death with preexisting conditions reported before surgery. Materials and Methods: In this retrospective cohort study, data from the Swedish National Death Register on patients, consecutively treated in the edentulous arch between 1986 and 2013, were compared with information from the patient files regarding the preexisting health conditions of the deceased patients. One-year survival rates were calculated and compared with expected mortality in a Swedish reference population based on three age groups: young (<45 years of age), middle-aged (45 to 64 years of age), and old patients (>64 years of age). Proportions of mortality between study groups and reference populations were tested by means of a log-rank test, and agreement between diagnoses before surgery and cause of death was tested by means of kappa test. Results: Altogether, 3,877 patients were included, of whom 60 patients died within 1 year after implant surgery (1.5%). The expected mortality in the Swedish reference population was 2.1% (P < .05). Mortality was higher for middle-aged (P=.02) but lower for old patients (P=.0001) compared with the Swedish reference populations. Eight of the deceased patients (13%) had no preexisting conditions, while 48 patients reported a health diagnosis before implant surgery. The most common of these were related to the circulatory system (ICD 10-I), which was the cause of death for 30 patients. A "none to slight agreement" between presurgical diagnoses and cause of death was observed in the population (kappa: 0.152). Conclusion: Edentulous implant patients presented overall lower mortality than expected in the general population during the first year after surgery. However, middle-aged patients showed a higher proportion of deceased patients compared with control people of the same age. Cardiovascular diseases were the cause of death in 50% of the group, and the agreement between presurgical and cause of death diagnoses was poor. Int J Oral Maxillofac Implants 2022;37:128–134. doi: 10.11607/jomi.9184

Keywords: age at surgery, causes of death, dental implant, early mortality, edentulous

Total hip replacement (THR) and total knee replacement (TKR) are currently common orthopedic implant procedures that have been validated by different national registers since the mid 1970s.1 Patient mortality after surgery is undoubtedly one of many crucial endpoints to report after implant surgery, especially from the patients’ point of view.2 Patient mortality after such procedures has been examined in several orthopedic follow-up studies.1,3–9 These have generally indicated reduced overall long-term mortality in large populations of patients who have had a THR or TKR compared with reference populations.1,3–9 The reduced mortality has in part been attributed to patient selection, and now, even fitter and more active patients are surgically treated.1,9,10 However, increased overall mortality for both THR and TKR patients has been reported for middle-aged patients aged between 50 and 60 years.1,7,11 Contrary to this, a reduced risk of mortality has been observed in older treated patients,1,7,11 but an increasing short-term mortality following primary THR and TKR has been reported with increasing age.5,7,8,12–14 Early as well as late deaths have often been associated with cardiovascular events in these patients.1,9,12,13

Loss of all teeth in the maxilla and/or mandible is one of the most severe clinical conditions in dentistry. For many years, patients were restored with removable complete dentures. However, an increasing number of edentulous patients have, for the last few decades, been restored with implant-supported prostheses with encouraging long-term results.15–17 Similar biologic bone healing has been described after both orthopedic and dental implants.18 Moreover, the patterns of implant

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1Brånemark Clinic, Public Dental Health Care Service, Gothenburg, Region of Västra Götaland; Department of Prosthetic Dentistry/Dental Material Science, Sahlgrenska Academy at Gothenburg University, Gothenburg, Sweden.
2Brånemark Clinic, Public Dental Health Care Service, Gothenburg, Region of Västra Götaland, Sweden.

Correspondence to: Dr Torsten Jemt, Brånemark Clinic, Medicinaregatan 12C, 40233 Gothenburg, Sweden. Email: torsten.jemt@vgregion.se

Submitted December 22, 2020; accepted May 12, 2021. ©2022 by Quintessence Publishing Co Inc.
failures and patient survival related to age at the time of surgery have been reported to show a comparable long-term pattern in the two groups of implant patients.\textsuperscript{1,7,11,19–24} Therefore, both orthopedic and dental implants that are placed in the edentulous jaw or knee and hip are reported to fail more often in younger and middle-aged patients than in the older patients in the long term.\textsuperscript{19,21,23,24} This is comparable to a similar trend of higher mortality in middle-aged patients in both groups.\textsuperscript{1,3–9,20–22} The increased risk of long-term patient mortality has also been associated with an increased risk of cardiovascular diseases (CVDs) in both orthopedic and edentulous implant groups.\textsuperscript{1,9,12,13,22} However, even though comparable patterns can be suggested after dental and orthopedic implant placement, there is limited knowledge of whether this risk pattern can be observed within the first year after dental implant surgery or not, and if the cause of death can be associated with systemic severe preexisting conditions identified before dental implant surgery. Further research on early mortality and the correlation with dental implant treatment is of interest to increase knowledge about the association between systemic health and implant treatment in edentulous patients.

Accordingly, knowledge of the early mortality patterns in edentulous implant patients is limited. The purpose of the study was to analyze patient mortality within the first year after surgery and compare the cause of death with preexisting conditions reported before surgery. The statistical null hypothesis was that there is no difference in early mortality between patients treated with implant-supported prostheses in the edentulous arch and the Swedish population, irrespective of age at surgery. The working hypothesis was that middle-aged edentulous implant patients may present a higher early mortality than the reference population in agreement with earlier long-term results in the population,\textsuperscript{22} and that preexisting health conditions reported in the files before implant surgery were in agreement with the recorded causes of death. The specific aims were to (1) compare mortality data retrospectively between a group of edentulous patients treated with implant-supported prostheses to the mortality in the Swedish population, (2) compare the early mortality frequency in different age groups within the study group and in the Swedish population, and (3) to investigate the agreement between general health data at implant surgery to the cause of early mortality.

**MATERIALS AND METHODS**

**Study Design**

The present study was a retrospective cohort study covering all edentulous patients consecutively treated at one referral clinic (Brånemark Clinic, Public Dental Health Service). The patients were included at the time when they first received implants in either the edentulous maxilla and/or mandible between January 1986 and December 2013. The patients were followed-up for 1 year after surgery regarding survival according to the Swedish National Cause of Death Register until December 2014. The study was approved by the local Ethics Committee in Gothenburg (#460-15).

The present edentulous patients are a subgroup of patients who have been accounted for in a previous publication.\textsuperscript{22} From the total number of patients treated at the clinic during the inclusion period, all patients treated in the partially edentulous arch were excluded. Thereafter, edentulous patients who were living abroad and were not recorded in the Swedish national population registers and patients who presented incomplete or missing files for recording of general health before implant surgery were excluded.

**Variables/Data Collection**

Information on the time and the cause of death was obtained from the Swedish National Cause of Death Register provided by the National Board of Health and Welfare in Sweden.\textsuperscript{22} The register is based on the International Statistical Classification of Diseases and Related Health Problems (ICD), where all codes were converted to the latest ICD-10 version.\textsuperscript{21} The same ICD-10 codes were used for classifying all patients reported as deceased within the first year after implant surgery (early mortality) with regard to their main general health problems or medications on examination at the clinic before implant surgery. Each patient was given a main block letter according to the ICD-10 code system—A to S or V, Z, or U—or the patient was reported as “healthy” with no identified preexisting conditions or medications at implant surgery (Table 1). This information in the files before implant surgery was compared with the main ICD-10 codes used to detail the cause of death.

**Data Analyses**

Calculations of survival rates for treated patients and the expected survival rates of a comparable group of patients, based on data from the entire Swedish population, have been described in earlier publications.\textsuperscript{20–22} In brief, data on expected patient survival in the total population were obtained from Statistics Sweden and the National Board of Health and Welfare for each patient.\textsuperscript{20–22} Individual expected survival data were used to calculate the expected survival for the Swedish reference populations. The expected 1-year survival rate for each individual patient was recorded based on age at surgery, sex, and year of surgery for the Swedish population register.\textsuperscript{20–22} The expected survival for groups of treated patients (reference) was compared to the observed survival of presently treated patients.\textsuperscript{20,21}
Patients < 45 years of age were denoted as “young,” those between 45 and 64 years of age as “middle-aged,” and those > 64 years of age as “old.” The patients were also arranged into two groups for additional statistical analyses: “young” (< 65 years of age) and “old” (> 64 years of age).

Statistical Analyses
Data are presented as numbers, frequencies, percentages, means, and standard deviations (SD). Overall, background data on patient survival in the total and remaining excluded partially edentulous groups (1986 to 2013) was also compiled and reported. A log-rank test was used to test the difference in mortality between expected (reference) and observed mortality in different patient and age groups. Agreement between presurgical general health diagnoses and cause of death was tested by means of kappa test. Significant difference was set to .05.

RESULTS
Altogether, a total of 8,731 patients were provided with 40,078 implants during 11,121 implant operations in the referral clinic from 1986 to 2013. Three thousand nine hundred six patients remained after exclusion of those who received implants in the partially edentulous arch (4,825 patients). Another 29 and 23 edentulous patients were excluded since they were living abroad or presented incomplete files, respectively.

Accordingly, the present study group comprised 3,877 patients who had been provided with implants in one or both edentulous arches at first implant surgery at the clinic. The mean age was 64.3 (SD: 11.2) years of age, with ages ranging from 17 years to 97 years at implant surgery (Figs 1 and 2). Two thousand one hundred thirty-nine of the patients were female (55.2%). All patients who died within the first year after implant surgery were identified and formed the present study group.

In total, 2,843 patients were reported as deceased in the clinic from 1986 to the end of 2014, of whom 2,098 were edentulous (73.8% of all deceased patients/54.1% of the edentulous patients), and 745 were partially edentulous (26.2% of all deceased patients/15.4% of the partially edentulous patients). Seventy-three patients died during the first year after implant surgery, of whom 60 were edentulous in the maxilla and/or mandible (survival: 98.5%), and 13 were partially edentulous (1-year CSR: 99.7%). The expected 1-year survival was 97.9% and 99.0% for people in reference populations of the same distribution of age and sex in Sweden, respectively.

Thirty of the deceased edentulous patients were women, and 30 were men. The mean age at surgery was 70.9 (SD: 11.4) years, with ages ranging from 42 to 91 years in this group. The overall survival in the edentulous group of patients showed a higher survival rate than the corresponding Swedish reference population (P < .05). Young patients (< 65 years) presented a higher mortality, and old patients (> 64 years) presented a

<table>
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<th>ICD code</th>
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<th>Preoperative</th>
<th>Cause of death</th>
<th>Conformance</th>
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Table 1: Number of Patients with Different International Classification of Diseases (ICD) Codes Reported Before Surgery and as the Cause of Death.

The number of patients with the same diagnosis before surgery, as was reported as the cause of death, is presented in the column “conformance” (kappa: 0.152; “none to slight agreement”).

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lower mortality than reference populations \((P < .05)\), respectively. Regarding age groups (young/middle-aged/old), middle-aged edentulous patients showed a higher mortality than expected \((P = .02)\), while patients in the old age group showed lower mortality \((P = .0001; \text{Fig } 3)\). The mean time from implant surgery to the death of the deceased patients within the first year was 251 (SD: 93.4) days, with a range from 15 to 354 days (Fig 4). Eight patients died within 90 days (0.2%) and 20 patients within half a year (0.5%). The corresponding expected mortality in a comparable Swedish reference population after 90 days and half a year was 0.4% and 0.8%, respectively.

Data on preexisting medical conditions and medication before implant surgery were missing for four patients, and another eight patients reported that they were not on any medication or had any general health problems (Table 1). The remaining 48 patients had preexisting conditions before surgery, of which most related to CVD (Table 1; ICD code-10; I). Twenty of the deceased patients had the same ICD code for cause of death as was reported as their main general health problem before surgery. CVD was also the most common cause of death in the group (ICD-I), followed by different types of cancer (Table 1). Cancer was reported as the cause of death in five (26%) and nine (23%) patients in the middle-aged and old groups, respectively. The proportion of CVD as the cause of death was the same in both groups (53%). “None to slight agreement” was observed between diagnoses before surgery and cause of death (kappa: 0.152).
DISCUSSION

This study aimed to investigate early patient mortality after implant surgery in the edentulous maxilla and/or mandible, and to compare the recorded cause of death with preexisting conditions reported before surgery. The working hypothesis was that young patients present higher early mortality than a Swedish reference population and that there was good agreement between presurgical diagnosis and reported cause of death. The present results from the short observation period demonstrated a similar risk pattern as reported earlier after long-term follow-up in edentulous implant patients, that is, lower overall mortality compared with a reference population, higher mortality for middle-aged patients ($P < .05$), and that CVD is the leading cause of death in the group (Fig 2, Table 1).20–24 Accordingly, groups of middle-aged edentulous patients may include patients with a higher risk for early/late mortality, but risk evaluation of early death based on presurgical anamnestic information may be difficult (kappa: 0.152; “almost no agreement”). More presurgical clinical consultations for general cardiovascular examinations may be considered for middle-aged edentulous patients.1

Cancer is the most common cause of death in the middle-aged Swedish reference population, which is not in agreement with the present study group.22 Instead, CVD was more common as the cause of death in both the middle-aged and old group of edentulous patients (Table 1). Gordon et al26 suggested that, “The pathogenesis of cardiovascular disease is causally related to inflammatory processes,” and that the risk for CVD is “associated with an inflammatory activity such as rheumatoid arthritis or dental health.”26 The authors also stated that “primary osteoarthritis has moved from being perceived as a wear-and-tear condition to an inflammatory disease.”26,27 Furthermore, Robertsson et al1 discussed the relative overrepresentation of cardiovascular mortality in their population study on 65,515 TKR patients, compared to patients with rheumatoid arthritis, low-grade inflammation, and anti-inflammatory medications.1,26–33 This is in agreement with the findings of the present study, where a high prevalence of CVD was found as the cause of death (Table 1). Recently, it was suggested that genetic disposition associated with a general inflammation susceptibility could be a common factor.24,34 The stronger the overall inflammatory response the patients have, the earlier and stronger the inflammatory response would be observed in middle-aged patients.24,34 If this is the case, it has been recommended that there needs to be increased control regimes, and subsequent treatment is recommended to lower the risk of severe inflammation-driven diseases such as CVD in these middle-aged edentulous TKA and THA patients.1,24,35–37

It has been reported that the risk of future general health problems, mainly CVD and early mortality, could be associated with an early event of TKA and THA surgery, caused by rheumatoid arthritis and primary osteoarthritis, which are both considered to be inflammation-driven diseases.1,8,26,29 Similar observations suggest that an increased risk of CVD may be associated with periodontitis diseases and early loss of teeth.36–38 Accordingly, this increased risk pattern has also been reported for edentulous patients who lost teeth due to periodontitis many years earlier, and for patients provided with implants in the edentulous arch in their middle age.22,37 In the literature, it has been suggested that the increased risk of mortality is caused by periodontal inflammation per se even though CVD and death are observed many years after complete tooth loss.39,40 Periodontal inflammation is then assumed to be “accumulated” and possibly cause future CVD and early mortality many years later in the edentulous patients who lost teeth early.39,40 However, this explanation may be difficult to extrapolate to middle-aged TKA and THA patients, who also have a similar risk pattern, including an increased risk of CVD and mortality after
an early event of implant surgery due to other inflammation diseases.\textsuperscript{126-33} Alternatively, middle-aged patients showing early incidence of TKA, THA, or early tooth loss could have a predisposition for a too-strong inflammatory response, which may lead to early replacement of lost teeth, as well as increased risk of CVD and early mortality.\textsuperscript{22,24,34,36,38} The inflammation pattern is a complex and multifactorial problem to study, and further research is needed to understand the causal relationships.

The reasons why these patients lost their teeth and whether this tooth loss occurred in association with the surgical implant intervention or earlier is not clear and must be considered as a methodologic bias in this study.\textsuperscript{23,24} However, the present study included patients who could not be treated before all teeth were lost, and the age at surgery could be considered as a pertinent indication of at what age they became edentulous, especially regarding the younger patients in the study group.\textsuperscript{24} Another limitation is that there are no comparable studies available in the dental field, and several studies from the orthopedic field have been referred to instead. Certainly, the risk of early death in association with surgical treatment differs depending on the type of surgical intervention conducted and the health and age of the treated patients. When preexisting conditions are severe, or the surgery is extensive, higher in-hospital mortality can be observed, as can be exemplified during and after open heart surgery.\textsuperscript{41,42} However, TKA and THA surgery have shown a lower risk of in-hospital death, below 1%, which indicates an only moderate increased risk compared with reference populations.\textsuperscript{8,9,10,12,43} This early risk of mortality seems to be reduced in later performed operations.\textsuperscript{44} Gaston et al\textsuperscript{45} reported that an “increasing age was the only significant risk factor for early mortality” in patients after THA, but that “overall long-term mortality following THA was less than expected from the reference population, even in the subgroup with a coronary history.”\textsuperscript{46} In the present study, the risk of early mortality is lower than after orthopedic surgery, which may be expected. Furthermore, even though more old than young patients died after surgery in the present group, there are no indications of increased risk in older patients relative to reference populations (Figs 2 and 3). This is contrary to what Gaston et al reported in THA patients.\textsuperscript{45} Only one patient died in close association with surgery in the present clinic (Fig 3; 15 days later), and this event was analyzed in a separate investigation performed by the Swedish National Board of Health and Welfare. The investigation could not identify any signs of a causal relationship between the implant surgery and the death of the patient. Accordingly, it can be assumed that dental implant surgery involves a low or almost insignificant risk of major general health problems and the risk of death. This may be related to patient selection in a relatively healthy group of edentulous patients. If a higher number of old, fragile patients had been treated with implants, a different risk pattern may be expected. Thus, the mortality patterns of the first year after surgery could in the present, generally healthy and motivated, patient group be expected to be comparable to or lower than that which is observed in a reference population. However, middle-aged edentulous patients may have a small increased risk of mortality (Figs 2 and 3). This risk should be considered even when the patients report no general health problems before surgery.

CONCLUSIONS

It can be concluded that the null hypothesis was rejected and that there is a difference in early mortality between patients treated with implants in the edentulous arch and reference populations related to age at implant surgery. Older patients presented a lower risk, while younger patients could be considered as patients with an increased risk of early mortality compared with a Swedish reference population of comparable age. CVD was the leading cause of death in the total group, but there was almost no agreement between presurgical diagnoses on general health and cause of death. Further studies are needed to confirm the observations of this study and to further identify factors that are correlated to patients with increased risk of early mortality.

ACKNOWLEDGMENTS

This study has been supported by grants from Nobel Biocare Servic es. The authors reported no conflicts of interest related to this study.

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