Patterns of Mortality in Patients Treated with Dental Implants: A Comparison of Patient Age Groups and Corresponding Reference Populations

Torsten Jemt, DDS, Odont Dr, PhD[a,b]/Jan Kowar, DDS[b]/
Mats Nilsson, PhD[c]/Victoria Stenport, DDS, Odont Dr/PhD[b,d]

Purpose: Little is known about the relationship between implant patient mortality compared to reference populations. The aim of this study was to report the mortality pattern in patients treated with dental implants up to a 15-year period, and to compare this to mortality in reference populations with regard to age at surgery, sex, and degree of tooth loss. **Materials and Methods:** Patient cumulative survival rate (CSR) was calculated for a total of 4,231 treated implant patients from a single clinic. Information was based on surgical registers in the clinic and the National Population Register in Sweden. Patients were arranged into age groups of 10 years, and CSR was compared to that of the reference population of comparable age and reported in relation to age at surgery, sex, and type of jaw/dentition. **Results:** A similar, consistent, general relationship between CSR of different age groups of implant patients and reference populations could be observed for all parameters studied. Completely edentulous patients presented higher mortality than partially edentulous patients ($P < .05$). Furthermore, implant patients in younger age groups showed mortality similar to or higher than reference populations, while older patient age groups showed increasingly lower mortality than comparable reference populations for edentulous and partially edentulous patients ($P < .05$). **Conclusion:** A consistent pattern of mortality in different age groups of patients compared to reference populations was observed, indicating higher patient mortality in younger age groups and lower in older groups. The reported pattern is not assumed to be related to implant treatment per se, but is assumed to reflect the variation in general health of a selected subgroup of treated implant patients compared to the reference population in different age groups. *Int J Prosthodont 2015;28:569–576 doi: 10.11607/ijp.4644*

Dental implants are used as anchorage for prostheses that replace lost teeth. Teeth are lost as a result of trauma or any of various dental diseases, and in recent decades an association has been reported between number of missing teeth and different general diseases.[1–6] Accordingly, it has been suggested that the health of a patient's oral cavity mirrors the overall health of the patients,[7] showing a relationship "between developments in oral and general health among older people."[8] In line with these observations, an association has also been reported between number of remaining teeth and patient mortality, showing increased mortality with higher number of lost teeth.[6,9–16] For example, Österberg et al concluded that "number of teeth is a significant predictor of 7-year mortality in 75-year-old women independently of a number of factors related to lifestyle, disease, and reduced functional capacity."[11] Furthermore, Cabrera et al concluded that "number of missing teeth, independently of socio-economic status variables (the husband's occupational category, combined income, and education) was associated with increased all-cause mortality and cardiovascular disease, respectively."[6]

[a]*Professor, Department of Prosthetic Dentistry/Dental Material Science, Institute of Odontology, Sahlgrenska Academy at Göteborg University, Göteborg, Sweden.*
[b]*Prosthodontist, Brånemark Clinic, Public Dental Health Service, Region of Västra Götaland, Sweden.*
[c]*Statistician /Epidemiologist, Futurum, County Hospital Ryhov, Jönköping, Sweden.*
[d]*Associate Professor, Department of Prosthetic Dentistry/ Dental Material Science, Institute of Odontology, Sahlgrenska Academy at Göteborg University, Göteborg, Sweden.*

Correspondence to: *Dr Torsten Jemt, Brånemarkkliniken, Medicinaregatan 12C, SE 413 90 Göteborg, Sweden. Email: torsten.jemt@vgregion.se*

Along the same lines, recent data from two different implant studies suggest a relationship between age at implant treatment and patient mortality.[15,16] Kowar et al[16] confirmed earlier studies that concluded that partially edentulous elderly patients treated with implants presented a lower mortality than treated fully edentulous implant patients, but also that elderly implant patients as a group showed lower mortality compared to a reference population of comparable age. These observations were further supported by Friberg and Jemt,[15] who reported in another study on edentulous patients treated with implants that elderly patients presented a lower mortality compared to a reference population, but here also younger edentulous patients presented higher mortality than a reference population of comparable age. These two studies indicate a possible pattern of mortality in implant-treated patients with regard to age at treatment where younger patients seem to show higher mortality and older patients lower mortality than the comparable reference population.

The aim of the present study was to report the mortality pattern in a larger group of patients treated with dental implants and to compare this pattern to mortality in reference populations with regard to age at surgery, sex, and degree of tooth loss. The hypothesis was that there is an association between patient age at implant surgery and patient mortality compared to reference populations, as indicated in previous studies.

Materials and Methods

The present study is a retro-prospective study[17] based on patient registers covering all implant patients provided with implants consecutively treated on a routine basis at one specialist clinic (Brånemark Clinic, Public Dental Health Service, in Region of Västra Götaland, Sweden) during the period from January 1986 to December 1997 (12 years).[18] Another group of patients treated with implants only in the edentulous jaw between January 2004 and December 2008 were identified as well for presenting possible consistency of observed results over time. The present study has been approved by the local ethical committee in Göteborg, Sweden (reg no. 197-12).

From these registers, total numbers of patients and total numbers of implant operations were retrieved. Data from identified patients were retrieved from the surgical registers with regard to time at surgery, age at implant surgery, sex, and type of treated jaw (maxilla/mandible and partially/fully edentulous). Patients who were surgically treated several times at the clinic were included as identified at the time of their first surgery. Accordingly, if the patient was first treated for an edentulous maxilla, this patient is categorized for data purposes as a patient with an edentulous maxilla (edentulous patient) and any treatment in the mandible is not included. If the patient was treated the first time with one or more implants in the partially edentulous maxilla, this patient is recorded as a patient treated in a partially edentulous maxilla (partially edentulous patient) and any further implant treatment is not addressed. Data on numbers of patients treated multiple times with implants in one or both jaws havebeen accounted for in a previous study.[18] Patients with major bone grafts placed under general anesthesia in the hospital, patients from abroad (n = 50), and patients who emigrated after implant surgery (n = 42) were excluded from this study.

Information on whether the patients were alive or deceased was collected from the official national Swedish population database (Västfolket) from time of implant surgery to May 2014. When patients were deceased, the date was noted and used for calculation of patient cumulative survival rate (CSR) during follow-up.[15,16] Furthermore, as described in earlier studies,[15,16] information was collected for each individual patient regarding remaining life expectancy at the time of implant surgery using life tables on the Swedish population.[19–21] Based on this data for individual patients, an expected mean CSR was calculated for a reference group of the Swedish population (reference population CSR). CSR for the reference group was based on survival data for the entire Swedish population, including persons of the same age and sex at the same time as the patient. Thereafter, calculated CSR data for patients and reference populations were compared for different age groups based on age at time of surgery.

Statistical Analyses

In the present report, descriptive data are presented as numbers, frequencies, means, and standard deviations. Patients were grouped according to age (20 to 29, 30 to 39, 40 to 49, 50 to 59, 60 to 69, 70 to 79, and 80 to 89 years) and by type of treated jaw (partially or fully edentulous; maxilla or mandible). Life table calculations have been used (Kaplan-Meier analysis) to estimate survival stratified by age group and degree of edentulism (fully or partially edentulous) in the treated jaw in relation to mortality in the reference population. Log-rank and chi-square tests were used to test differences in survival between the reference population and treated patients. CSR for the Swedish population was used to calculate mortality in the age-specific reference groups. The calculated *P* values were considered statistically significant if $P < .05$.

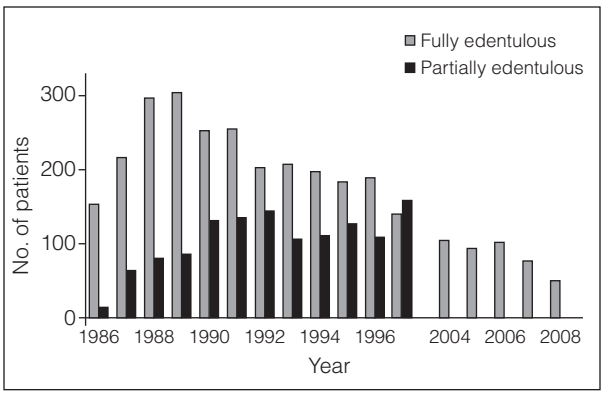

Fig 1 Number of treated fully and partially edentulous patients per year during the two treatment periods, 1986 to 1997 and 2004 to 2008. Note that the year axis is truncated.

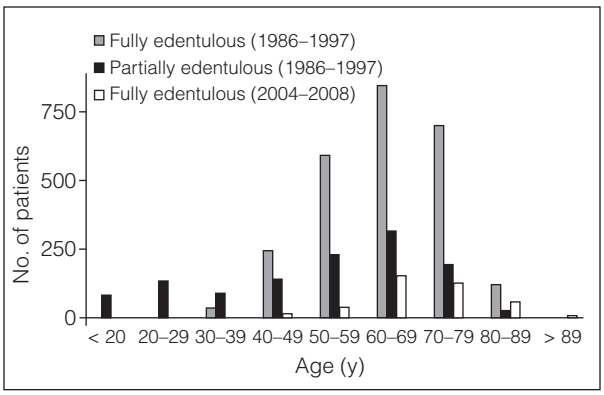

Fig 2 Age distribution among fully and partially edentulous patients at time of first treatment.

Results

A total of 4,267 patients were consecutively treated with implants and included for follow-up during the periods included in the present study. Of these patients, 36 were not possible to identify in the national population register (0.8%). The remaining 4,231 patients followed up in the present study are accounted for with regard to age group, type of treated jaw, and period of inclusion in Table 1 and Figs 1 and 2.

All partially and fully edentulous patients included from 1986 to 1997 (Table 1; n = 3,812) were followed up for at least 15 years. A total of 18 patients treated for a fully edentulous jaw (n = 2,568 patients) reached an age of 100 years or older (0.70%). Two patients treated for a partially edentulous jaw (n = 1,244 patients) reached an age of 100 years or older during follow-up (0.16%). Between the two groups, 2,097 patients were deceased (55.0%) during the entire 28 years of inclusion/follow-up. During the 15 years of follow-up, 1,241 patients were deceased (37.7%): 236 patients treated for a partially edentulous jaw (19.0%), and 1,005 patients treated for a fully edentulous jaw (39.1%).

In the fully edentulous group of consecutively treated patients with only 5 years of follow-up time (2004 to 2008), 57 patients were deceased during the first 5 years (13.6%), compared to 187 deceased patients (7.2%) for the original group of fully edentulous patients (1986 to 1997) after 5 years.

Fifteen-year life table survival curves were calculated for all age groups of patients from 40 to 89 years (Figs 3 to 5). Results of statistical comparisons between partially and fully edentulous implant patients and between patients and reference populations are presented for different age groups in Table 2. A consistently lower survival rate can be observed for all fully edentulous groups compared to partially edentulous patients. This difference was statistically significant for all groups ($P < .05$) except for 70 to 79 years (Table 2).

Table 1 Number of Patients and Median Age at First Implant Surgery in Different Age Groups of Partially and Fully Edentulous Jaws

Age group (y)	Partially edentulous		Fully edentulous (1986–1997)		Fully edentulous (2004–2008)	
	Patients (no.)	Median age (y)	Patients (no.)	Median age (y)	Patients (no.)	Median age (y)
< 20	86	18				
20–29	138	23	2	27		
30–39	93	35	40	37	3	36
40–49	145	46	249	46	18	46
50–59	234	55	596	55	42	54
60–69	198	65	850	65	158	66
70–79	198	73	704	73	131	75
80–89	30	83	125	82	61	83
> 89			2	92	6	91
Total	1122	57	2568	65	419	69

For fully edentulous patients, the survival rate was lower for the younger age groups (40 to 69 years) and higher for the older age groups (70 years and older) compared to reference populations (Figs 3 to 5). These differences were significant for all age groups ($P < .05$) (Table 2). The difference in survival rate between patients and reference populations showed a systematic increase with increased age (Fig 6). Patients treated for a partially edentulous jaw presented statistically significant lower mortality compared to reference populations in age groups older than 50 years (Table 2) and showed a similar pattern of increased difference with increased age (Fig 7). For age groups younger than 50 years, survival rates of partially edentulous patients were comparable to those of reference populations ($P > .05$) (Fig 7).

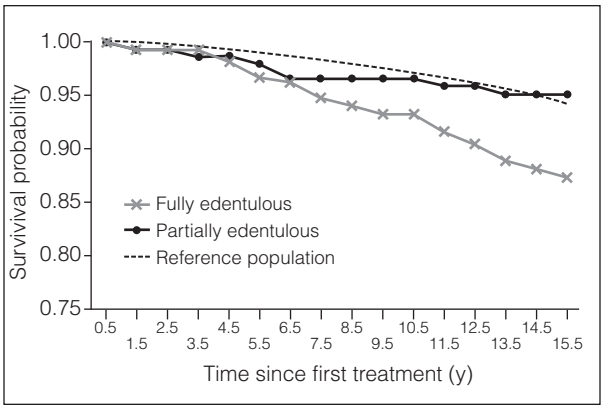

Fig 3 Life table survival curves for patients 40 to 49 years of age at first treatment for groups of fully and partially edentulous (1986 to 1997) patients compared to the reference population at the same age interval during 15 years of follow-up. Note that the axis for survival probability is truncated. Logrank test of difference in overall survival $P = .0005$.

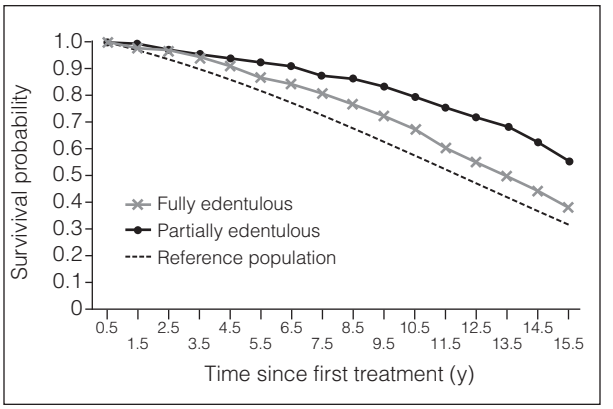

Fig 4 Life table survival curves for patients 70 to 79 years of age at first treatment (1986 to 1997) for groups of fully and partially edentulous patients, compared to the reference population at the same age interval during 15 years of follow-up. Logrank test of difference in overall survival $P < .0001$.

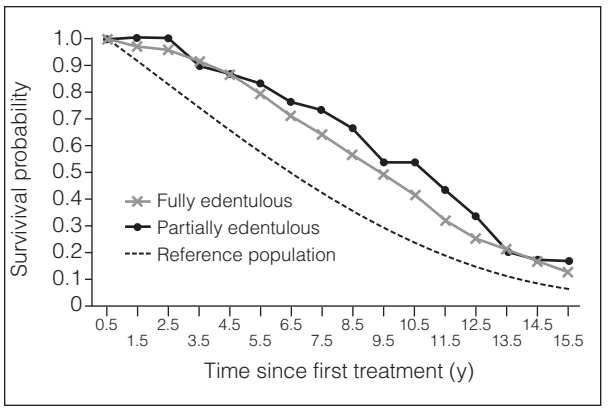

Fig 5 Life table survival curves for patients 80 to 89 years of age at first treatment (1986 to 1997) for groups of fully and partially edentulous patients, compared to the reference population at the same age interval during 15 years of follow-up. Logrank test of difference in overall survival $P < .0001$.

Table 2 Comparisons of 15-Year Survival Stratified by Age and Degree of Edentulism, Versus a Reference Population Based on Kaplan-Meier Life Table Curves

	Testing equal survival curves		
Age group (y)	Fully edentulous (E) vs partially edentulous (P)	Fully edentulous (E) vs reference population (R)	Partially edentulous (P) vs reference population (R)
40–49	E < P*, $P = .0006$	E < R, $P = .008$	P = R, $P = .6$
50–59	E < P, $P < .0001$	E < R, $P < .0001$	P > R, $P < .0001$
60–69	E < P, $P < .0001$	E < R, $P < .0001$	P > R, $P < .0001$
70–79	E = P, $P = .4$	E > R, $P < .0001$	P > R, $P < .0001$
80–89	E < P, $P < .0001$	E > R, $P < .0001$	P > R, $P < .0001$

*E < P indicates that fully edentulous patients have a significantly lower 15-year survival rate than partially edentulous patients ($P < .05$).

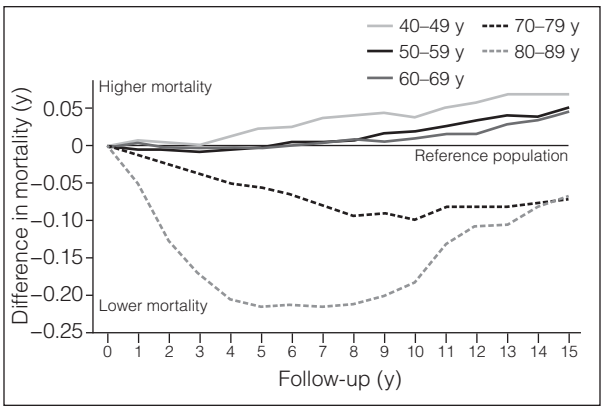

Fig 6 The difference in 15-year survival between reference population and patients in different age groups over time for fully edentulous patients treated between 1986 and 1997. The difference shows the highest mortality for the youngest age group, followed by a consistent shift toward lower mortality in older age groups. In the later part of the follow-up period, an increasing mortality in relation to the reference population can be observed in the oldest age groups.

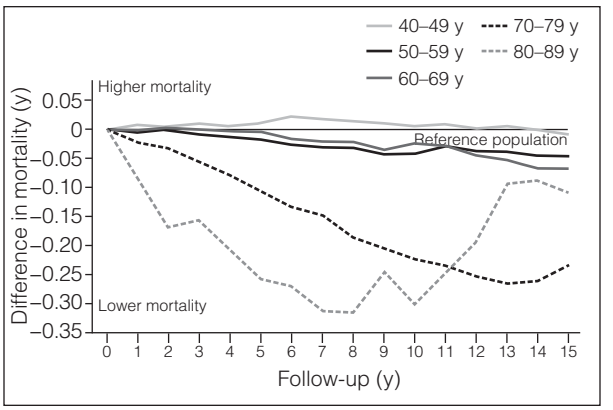

Fig 7 The difference in 15-year survival between reference populations and patients in different age groups over time for partially edentulous patients treated between 1986 and 1997. This group shows a similar pattern as that seen in fully edentulous patients.

Fig 8 Difference in survival between reference population and patients in different age groups of fully edentulous patients after 5 years of follow-up, divided into three different time periods. Data indicate a comparable mortality pattern over different periods for the same age groups, but the youngest patient group (40 to 49 years) in the latest period of treatment (2004 to 2008) showed a significantly higher mortality than in the two earlier treatment periods ($P < .05$).

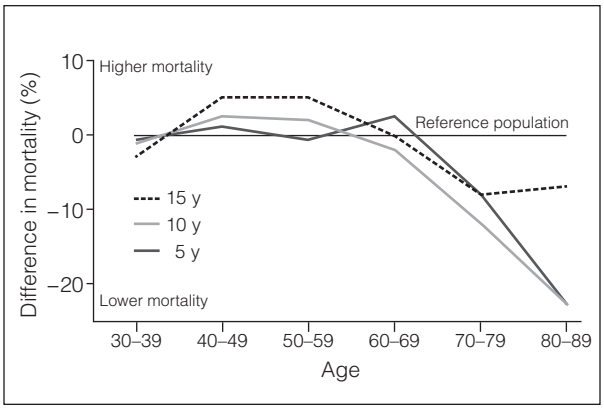

Fig 9 Difference in survival between reference population and patients in different age groups for fully edentulous patients treated between 1986 and 1997 after 5, 10, and 15 years of follow-up. Data indicate a comparable mortality pattern over time for the same age groups, but patients aged 40 to 59 years of age show higher mortality after 15 years than after 5 years, and the oldest age group shows a decreasing difference after 15 years than after 5 years.

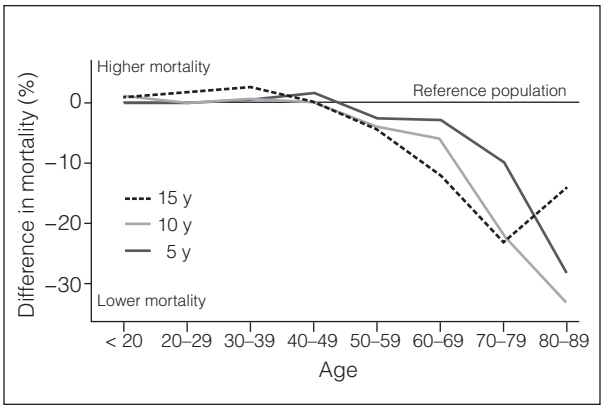

Fig 10 Difference in survival between reference population and patients in different age groups for partially edentulous patients treated between 1986 and 1997 after 5, 10, and 15 years of follow-up. Data indicate a comparable mortality pattern over time for the same age groups, but the youngest patients (20 to 39 years) show higher mortality after 15 years as compared to 5 years and the oldest age group shows a decreasing difference after 15 years than after 5 years of follow-up.

Fig 8 presents the differences for edentulous patients in age groups from 40 years to 80 years followed up for 5 years and treated during three different periods: 1986 to 1991, 1992 to 1997, and 2004 to 2008. A lower mortality was observed in the oldest age groups (80 to 89 years) compared to the reference population for all periods of treatment. Younger patient age groups showed similar or higher mortality compared to reference populations. Edentulous patients treated during the last period (2004 to 2008) presented a significantly higher mortality ($P < .05$) than the youngest age groups (40 to 49 years) (Fig 8).

Figs 9 and 10 show the pattern of difference in mortality between the reference population and patients after 5, 10, and 15 years of follow-up for fully (Fig 9) and partially edentulous patients (Fig 10), and Figs 11 and 12 show the same pattern for treatments in the maxilla and mandible for fully (Fig 11) and partially edentulous jaws (Fig 12).

Discussion

The present study was based on a total of 4,231 implant-treated patients. Only one clear and easily defined endpoint (patient mortality) was used during follow-up. The majority of patients were possible to follow up using the national population register, and drop-out patients were few over 15 years (< 1%). Included patients were consecutively treated at a single clinic, and to cover a large number of patients, which was considered necessary for the study design, a relatively long period of inclusion was used. This design also allows for analysis of the possible impact of time on inclusion and treatment of patients. Accordingly, the number of partially edentulous patients increased over time and the number of fully edentulous patients decreased, which is in line with general trends in implant dentistry (Table 1 and Fig 1). Furthermore, it was observed that the fully

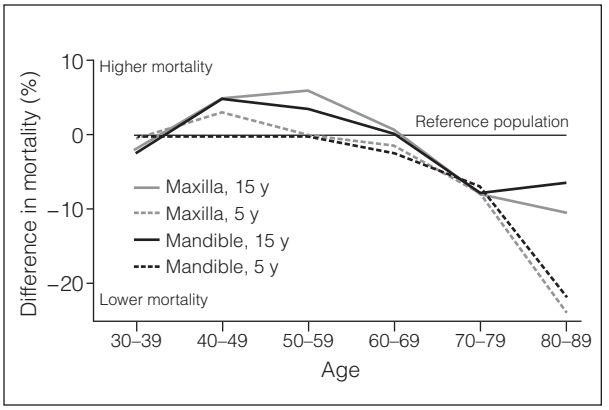

Fig 11 Difference in survival rate between reference population and patients in different age groups for fully edentulous patients treated between 1986 and 1997 after 5 and 15 years, by treated jaw. Data indicate a comparable mortality pattern over time for the same age groups, but patients aged 40 to 59 years show higher mortality after 15 years than after 5 years and the oldest age group shows a decreasing difference after 15 years than after 5 years.

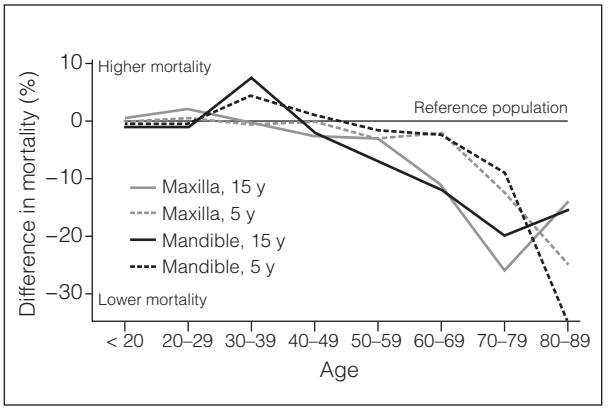

Fig 12 Difference in survival rate between reference population and patients in different age groups for partially edentulous patients treated between 1986 and 1997 after 5 and 15 years of follow-up by jaw treated. Data indicate a comparable mortality pattern over time for the same age groups, but a higher mortality for patients treated in the mandible as compared to the maxilla could be observed for the group aged 30 to 39 years. The oldest age group shows a decreasing difference in mortality after 15 years than after 5 years of follow-up.

edentulous patients were older in the more recently treated groups (Table 1), and it has also been reported that the period of edentulousness before implant surgery has decreased over time.[22] Accordingly, it could be assumed that the early fully edentulous patients show a wider range of time of edentulousness than patients in the latest group (2004 to 2008). Still, a consistent pattern of mortality was observed among the groups over a 5-year period, with an increased mortality only for the youngest fully edentulous patient group ($P < .05$), treated during the last period of inclusion (2004 to 2008) (Fig 8). Accordingly, a similar pattern of mortality can be observed for different periods of treatment, follow-up times, sex, jaws treated, and degree of edentulism.

Included patients were divided into two groups with regard to tooth loss: those with no teeth in the first treated jaw (fully edentulous) and those with teeth remaining in the first treated jaw (partially edentulous). This could be considered imprecise as numbers of remaining teeth could vary considerably among partially edentulous patients and no information is available on the dental situation in the opposing jaw. However, even with these obvious methodological limitations the results consistently show a significant difference in mortality between partially and fully edentulous patients in various subgroups ($P < .05$), in agreement with earlier studies based on total numbers of remaining teeth, where treatment per se has been disregarded.[5,9–16] Thus, with about 19% of the patients treated with implants in both jaws,[18] most with years between the operations, and where no precise control of total numbers of remaining teeth at first surgery is available, the present approach was considered accurate enough to show the difference in mortality between partially and fully edentulous patients, in accordance with earlier publications. In the study by Kowar et al,[16] a similar relationship to that reported in the present study was observed between two smaller groups of older patients who were either partially or fully edentulous in both jaws.

An obvious deviation was observed in patient mortality in relation to the expected pattern of mortality in reference populations. Earlier studies suggested an association between tooth loss and increased mortality,[5,9–16] which was also observed in a recent study on elderly implant patients.[16] The present data further support this observation with a consistent increase in mortality for fully edentulous patients compared to partially edentulous patients, in most groups reaching a statistically significant level (Table 2). This observation is also consistent with the observation of higher mortality compared to reference populations in fully edentulous age groups younger than 69 years (Table 2 and Fig 6). The trend seems also to be that more recently treated fully edentulous patients (2004 to 2008) show a higher risk of mortality than earlier treated fully edentulous patients in the youngest age group (40 to 49 years) (Fig 8). A reasonable interpretation of this observation could be that complete tooth loss at a younger age today is associated with a higher risk of compromised general health than it was 20 to 30 years ago.

A consistent pattern of higher mortality for fully edentulous patients would imply that older age groups of implant patients would show an increased

mortality. However, this was not observed in the present study (Table 2 and Fig 6), where older patients who were treated for a partially or fully edentulous jaw show a significantly decreased mortality ($P < .05$). This trend was more pronounced in the older age groups (Figs 6 and 7). Accordingly, the present results in elderly implant patients are not in line with the expected pattern of higher mortality associated with tooth loss,[6,9–16] but support earlier studies on implant patients from the same patient group[15,16] that also reported lower mortality for older age groups. Kowar et al[16] suggested that this reduced mortality may be due to the fact that in the older patient age groups, only the healthiest and most active patients ask for implant treatment, leaving the remaining edentulous patients with compromised health without implant treatment. Accordingly, it could be assumed that the lower mortality in the older age groups in the present study are not related to implant treatment per se, but more associated with patient inclusion from a larger group of edentulous older patients with various levels of general health and motivation.[16]

It was stated earlier that edentulousness can lead to chewing problems as well as feelings of insecurity and inferiority and considerable psychosocial problems, whereas implant treatment could significantly improve patients' quality of life and self-confidence.[23] Tooth loss may lead to a compromised quality of life that could be significantly improved by implant treatment. Patterns of mortality in populations are very complex and multifactorial, and differences in populations are difficult to interpret. Restoration of the dentition with implants plays a minor role, if any, in the observed reduced mortality in partially and fully edentulous elderly patients. Instead, it could be assumed that an individual elderly patient's interest in re-establishing mastication, oral function, and speech to improve self-confidence and social interaction is important. It could be meaningful for the patient to have good oral function not only for chewing but also for social reasons. Recent studies have addressed the importance of subjective well-being and suggested that "eudemonic well being (sense of purpose and meaning in life)" may even "have a protective role in health maintenance."[24] Accordingly, Steptoe et al[24] have reported that persons with the highest levels of eudemonic well-being showed an increased survival compared with persons with the lowest levels of well-being.[24,25] Furthermore, they showed that well-being varied among regions; for example, higher levels were found in Western Europe than in Eastern Europe for older age groups.[24] It is reasonable to assume that type and number of dental treatments may also differ among countries due to various factors. Recently, Davidson et al[26] reported that an increased level of reimbursement for elderly patients (65 years or older) within the Swedish National Dental Insurance system increased the volume of prosthetic treatment in these age groups after 2008. Whether these changes had any impact on the health profile of patients referred by general dentists to specialist clinics is not known. However, virtually no patients have been excluded from implant treatment due to general health at the clinic during the years, but some have been treated under general health observation at the hospital.

Longevity is here calculated from National Population registers, and incidence of centenarians in reference populations in Sweden has been estimated at 12.6 in 100,000 (0.016%) as of January 1, 2003.[27] Present population data indicate a total of 1,879 and 1,953 centenarians in Sweden in 2013 and 2014, respectively, corresponding to 0.019% and 0.020% of the total population.[19,20,21,28] However, it has been observed that the incidence of centenarians is much higher in certain geographical regions, which are called blue zones.[27] Among the patients included in the present study, 4 out of the 1,879 still alive at the termination of the study were 100 years old or older (0.21%), which is ten times higher than expected in the entire population. Accordingly, not only can a generally lower mortality in elderly implant patients be observed, but also that a higher proportion of these patients may reach an extremely advanced age compared with the general population. This potential therapeutic blue zone further emphasizes the special character of this elderly group of implant patients, for whom a strong interest in treatment may be a more important factor for longevity than the treatment itself.

Conclusions

Within the limitations of the present study and considering the complexity of population data on mortality patterns, the following conclusions could be made:

- Patients aged 69 years or younger treated for an edentulous jaw present significantly higher mortality compared to a reference population of comparable age ($P < .05$).
- Patients treated for a fully edentulous jaw present significantly higher mortality compared to patients treated for a partially edentulous jaw ($P < .05$).
- Implant patients in the younger age groups show a similar or higher mortality ($P < .05$) compared to that expected in reference populations. Increased mortality is especially pronounced in patients treated for a fully edentulous jaw in the latest period of inclusion (2004 to 2008) ($P < .05$).

- In comparison to reference populations, in patient age groups mortality is successively reduced from increased or equal in the youngest age groups to an obvious decrease in the oldest age groups ($P < .05$).

Acknowledgments

The authors acknowledge research assistant Marianne Spångberg, Brånemark Clinic, Göteborg, Sweden, for assistance in data compilation. The present study was supported by grants from Nobel Biocare, Zurich; Wilhelm and Martina Lundgren Research Foundation; and Sylwan Foundation. The authors reported no conflicts of interest related to this study.

References

1. Österberg, T, Mellström D, and Sundh V. Dental health and functional ageing. A study of 70-year-old people. Community Dent Oral Epidemiol 1990;18:313–318.
2. Paunio K, Impivaara O, Tiekso J, Mäki J. Missing teeth and ischaematic heart disease in men aged 45–64 years. Eur Heart J 1993;14 (suppl K):54–56.
3. Kondo K. Niino M, Shido K. A case-control study of Alzheimer's disease in Japan—significance of life-styles. Dementia 1994; 5:314–326.
4. Appollonio I, Carabellese C, Frattola A, Trabucchi M. Dental status, quality of life, and mortality in an older community population: A multivariate approach. J Am Geriatr Soc 1997;45: 1315–1323.
5. Joshipura KJ, Hung HC, Rimm EB, Willett WC, Ascherio A. Periodontal disease, tooth loss, and incidence of ischemic stroke. Stroke 2003;34:47–52.
6. Cabrera C, Hakeberg M, Ahlqwist M, et al. Can the relation between tooth loss and chronic disease be explained by socio-economic status? A 24-year follow-up from the population study of women in Gothenburg, Sweden. Eur J Epidemol 2005;20:229–236.
7. Heyden G. Health profile of the ageing population: The Swedish experience. Int Dent J 1998;48:167–172.
8. Mattsson U, Heyden G, Landahl S. Comparison of oral and general health development among institutionalized elderly people. Community Dent Oral Epidemiol 1990;18:219–222.
9. Hämäläinen P, Meurman JH, Keskinen M, Heikkinen E. Relationship between dental health and 10-year mortality in a cohort of community-dwelling elderly people. Eur J Oral Sci 2003;111:291–296.
10. Morita I, Nakagaki H, Kato K, et al. Relationship between survival rates and numbers of natural teeth in an elderly Japanese population. Gerodontology 2006;23:214–218.
11. Österberg T Carlsson GE, Sundh V, Steen B. Number of teeth—a predictor of mortality in the elderly? A population study in three Nordic localities. Acta Odontol Scand 2007;65:335–340.
12. Holm-Pedersen P, Schultz-Larsen K, Christiansen N, Avlund K. Tooth loss and subsequent disability and mortality in old age. J Am Geriatr Soc 2008;56:429–435.
13. Holmlund A, Holm G, Lind L. Number of teeth as a predictor of cardiovascular mortality in a cohort of 7674 subjects followed for 12 years. J Periodontol 2010;81:870–876.
14. Schwahn C, Polzer, I, Haring R, et al. Missing unreplaced teeth and risk of all-cause cardiovascular mortality. Int J Cardiol 2013;167:1430–1437.
15. Friberg B, Jemt T. Rehabilitation of edentulous mandibles by means of osseointegrated implants: A 5-year follow-up study on one or two-stage surgery, number of implants, implant surfaces, and age at surgery. Clin Implant Dent Relat Res 2015; 17:413–424.
16. Kowar J, Stenport V, Jemt T. Mortality patterns in elderly partially edentulous and edentulous patients treated with dental implants. Int J Prosthodont 2014;27:250–256.
17. Hall JC, Hall JL. Emergence of 'retropro' studies in the surgical literature. ANZ J Surg 2008;78:411–413.
18. Jemt T, Olsson M, Stenport V. Incidence of first implant failure: A retroprospective study of 27 years of implant operations at one specialist clinic. [epub ahead of print] Clin Implant Dent Relat Res 2014;10.1111/cid.12277.
19. StatisticsSweden, Population Changes 1988. Part 3. The whole country and the counties etc. Statistics Sweden, 1989.
20. StatisticsSweden, Population Statistics 1992. Part 4. Vital Statistics. Statistics Sweden, 1993.
21. StatisticsSweden, Population Statistics 1997. Part 4. Vital Statistics. 1998, Statistics Sweden.
22. Jemt T, Stenport V, Friberg B. Implant treatment with fixed prostheses in the edentulous maxilla. Part 1: Implants and biologic response in two patient cohorts restored between 1986 and 1987 and 15 years later. Int J Prosthodont 2011;24:345–355.
23. Blomberg S, Lindquist LW. Psychological reactions to edentulousness and treatment with jawbone-anchored bridges. Acta Psychiatr Scand 1983;68:251–262.
24. Steptoe A, Deaton A, Stone AA. Subjective wellbeing, health, and ageing. Lancet 2015;14;385(9968):640–648.
25. Steptoe A, Breeze E, Banks J, Nazroo J. Cohort profile: The English longitudinal study of ageing. Int J Epidemiol 2013;42:1640–1648.
26. Davidson T, Rohlin M, Hultin M, et al. Reimbursement systems influence prosthodontic treatment of adult patients. Acta Odontol Scand 2015;73:414–420.
27. Poulain M, Pes GM, Grasland C, et al. Identification of a geographic area characterized by extreme longevity in the Sardinia island: The AKEA study. Exp Gerontol 2004;39:1423–1429.
28. Sweden Statistics. Sveriges folkmängd (i ettårsklasser) 1860-2015. SCB, 2015-02-19. http://www.scb.se/sv_/Hitta-statistik/Statistik-efter-amne/Befolkning/Befolkningens-sammansattning/Befolkningsstatistik/25788/25795/Helarsstatistik---Riket/105505/