An 18-Year Retrospective Survival Study of Full Crowns With or Without Posts

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Purpose: This study of full crowns investigated long-term survival in relationship to biologic and technical variables. ***Materials and Methods:*** A total of 1,037 full crowns in 456 patients, made in an undergraduate university clinic, were evaluated over an 18-year period. All patients were offered a supportive maintenance program. Failures of full crowns were classified as irreversible (loss of full crown and/or tooth) or reversible (full crown intact after conservative treatment) complications and as biologic or technical/patient-related failures. ***Results:*** The Kaplan-Meier survival rate after 18 years was 78%. No statistically significant differences were found between restorations in the maxilla and mandible ($P = .150$); between restorations on molars, premolars, and anterior teeth ($P = .671$); and between restorations on posts and cores compared to restorations without posts and cores ($P = .602$). For the surviving restorations, the improved plaque score over time was statistically significant ($P = .001$). Biologic failures (66.4%) resulting in removal were more common than technical and patient-related failures (33.6%). Caries was the most frequent reason for failure (irreversible complication). ***Conclusion:*** The survival of full crowns made in an undergraduate university clinic during an 18-year period is comparable to the results published by university departments or private practitioners. Plaque scores and bleeding on probing were not directly related to failures. Occurrence of a previously reversible complication is a predicting factor for an irreversible complication. A reversible complication within the first 2 years will probably lead to an early irreversible complication. *Int J Prosthodont 2006;19:136–142.*

Full crowns on a natural tooth or on a dental implant as abutment form a considerable part of the field of restorative dentistry. This restoration is part of an anatomic and physiologic complex and plays an important role in the preservation of the gingiva, the periodontium, and the underlying bone. For these reasons some authors prefer to transplant a tooth instead of using a dental implant.[1] The complex biologic features of the papilla and gingiva and the biologic width[2,3] continue to make the use of a natural tooth as abutment a primary goal.

For the general practitioner, the use of full crowns on natural teeth is still common. In most cases a full crown is the treatment of choice and for the patient it is the optimal solution to achieve an esthetic result. Teeth may be crowned as abutments in patients who are in need of a removable partial denture.[4] Dental caries or trauma is often associated with extensive loss of tooth structure. Insufficient anchorage in the remaining dentin, as result of this coronal destruction, often leads to a root canal–retained restoration. This field of the full crown has been extensively studied, both

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in vitro and in vivo. Creugers et al[5] and Heydecke and Peters[6] concluded that no randomized clinical trials were available for their reviews on the restoration of endodontically treated teeth. Fernandes and Dessai[7] drew the conclusion that there is a need for controlled prospective clinical studies evaluating each factor that affects the fracture resistance of post-and-core reconstructed teeth.

Defining the effectiveness of fixed restorations and determining their mean lifespan are the main goals of a survival study. These data are important, as they provide the patient and the practitioner with valuable prognostic information and are useful in quality control. Various factors govern the longevity of restorations. Failures can be attributed to biologic factors or to technical and patient-related factors. Based on the literature, however, it remains difficult to draw specific conclusions.[8–10] The most substantial differences between studies are found in the definition of failure[11,12] and in study design. In addition, the populations studied have come from both private practices and university clinics. At dental schools, practitioners may be undergraduate dental students or graduate prosthodontists, whereas the populations of private practices are those from the general practitioners and those from the specialized prosthodontic practitioners. Most of these study populations have been called a methodologic disadvantage or of limited value for the general practitioner[9,13]—or on the other hand, they may be considered important and/or comparable.[14–16] Longitudinal studies are difficult to perform and evaluate, due to the high number of dropouts. Stability of a studied population is indeed important for the results of a longitudinal survival study.[17,18]

The aim of this long-term study was to investigate the survival of full crowns with or without posts in relation to some biologic and technical variables.

Materials and Methods

Materials

A total of 1312 full crowns were fabricated over a period of 18 years—between 1974 and 1992—in the undergraduate clinic of the former Department of Fixed Prosthodontics and Periodontology, University of Ghent. Complete treatment and follow-up records of 456 patients (60.5% women and 39.5% men), with a mean age of 41 years (range, 18 to 82 years) and a mean survival evaluation time of 10.0 years (range, 0.3 to 25.0 years), who had received 1,037 full crowns were available for analysis, representing 79% of the total number. The dropout rate of 21% was on account of the following reasons: patients chose a private practitioner for maintenance, moved to another city, could not be traced, or died during the follow-up period. None of the patients in the dropout group were contacted by telephone, and no questionnaires were sent, either to the patients or to former or current clinicians of these patients, to collect supplementary information. The crowns were either cast gold or porcelain-fused-to-gold. All impressions were made in a custom tray with a polyether material (Impregum, Espe). For post-and-core crowns, an impression of the root canal was taken with the help of a lentulo, but no other devices, such as burnout posts, were used. All post-and-core crowns were cast in a single piece in a gold alloy. All full crowns were cemented zinc phosphate (Harvard, Richmond Harvard). In the present study, no distinction was made between the different types of full crowns. Approval was given for the protocol of this study, project EC UZG 2005/100, by the Ethics Committee, OG 017, University Hospital, Gent, Belgium.

Methods

All patients were invited to participate in a regular supportive maintenance program every 6 months. During these maintenance sessions, a number of diagnostic and therapeutic steps were undertaken: whole mouth plaque scores after staining with a dichotomous reading (PI), bleeding on gentle probing of the gingival sulcus (BOP), periapical radiographs, recording of new caries lesions or secondary caries, control of the retention of the restoration, and recording of mechanical failures. Probing depth at 6 or 8 sites per tooth was recorded using a Michigan periodontal probe. At each session patients were re-instructed in plaque control, and plaque, supragingival calculus, and subgingival calculus were removed. Patients were scheduled for scaling and root planing when this was periodontally indicated.

At evaluation time, the study population was divided into 3 groups according to past caries experience, reflecting past caries sensitivity. Group 1 was the caries-nonsensitive group, with a maximum of 5 filled teeth, no proximal sites filled, and no endodontically treated teeth owing to caries. Group 2 was a moderately sensitive group, with a maximum of 10 teeth filled and 2 endodontically treated teeth owing to caries. Group 3 was the caries-sensitive group, with patients who had more than 10 restorations and/or more than 2 endodontically treated teeth owing to caries.

Failures were divided into biologic or technical/patient related failures and into reversible or irreversible complications. Caries, periodontal problems, fracture of the abutment tooth, and endodontic problems were considered biologic failures. Fracture of porcelain, loss of retention, fracture of the post, need for the tooth as

Table 1 Frequency Distribution of Full Crowns (FC) Placed Per Patient and No. of FCs Failed (1) or Surviving (0) Within the Same Patient

No. of FC/patient	No. of failures	No. of patients
1 (48.5%)	0	189
	1	32
2 (21.5%)	0	84
	1	11
	2	3
3 (12.5%)	0	43
	1	9
	2	3
	3	2
4 (7.0%)	0	28
	1	1
	2	2
	4	1
5 (3.7%)	0	9
	1	6
	3	2
6 (2.6%)	0	7
	1	4
	2	1
7 (1.3%)	0	4
	1	1
	3	1
8 (1.3%)	0	2
	1	1
	2	1
	3	1
	5	1
9 (0.4%)	0	1
	1	1
10 (0.7%)	0	2
	2	1
11 (0.2%)	1	1
15 (0.2%)	0	1

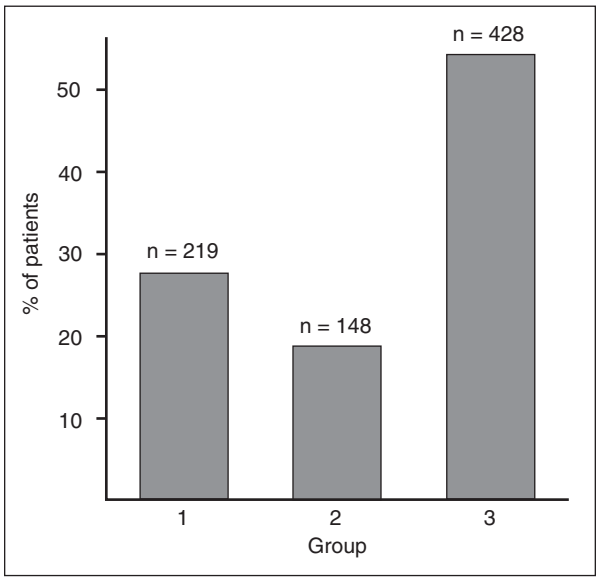

Fig 1 Past caries sensitivity, as recorded at evaluation: 1 = caries-nonsensitive group, 2 = moderately caries-sensitive group, 3 = caries-sensitive group.

abutment for a fixed partial restoration, and trauma were considered technical or patient-related failures. Failures were also classified as *irreversible,* if the full crown or the tooth were lost, or *reversible*, with recementation needed after loss of retention or endodontic treatment or a filling on the abutment tooth, with the full crown still intact. A full crown could therefore have a reversible complication but nevertheless end up in the surviving group at the final evaluation or could have a reversible complication followed by an irreversible complication, thus ending up in the failing group.

Statistical Analysis

The survival estimation method of Kaplan and Meier[19] was used. The log-rank test was used to discover whether some survival functions differ for different groups.[20]

The Wilcoxon matched-pairs signed-ranks test was used for the difference in patients between the PI and the BOP versus failing or surviving restorations. A logistic regression analysis with failure as the dependent variable was used in association with PI and BOP and the Community Periodontal Index for Treatment Needs (CPITN). The statistical significance of differences was calculated using a chi-square test. The significance level was set at $\alpha = .05$.

Results

The most common reasons for full crown preparation were extensive loss of crown substance because of caries (65.9%), replacement of an already existing restoration (12.2%), trauma (7.7%), endodontic problems (6.3%), or esthetic reasons (5.4%). The most common type of preparation was the post-and-core crown (79.2%). Porcelain-fused-to-gold crowns were indicated in 75.8% of crowns and full cast crowns in 24.2%. Of the full crowns, 27.6% were in the mandible and 72.4% were in the maxilla. Thirty-eight percent of the full crowns were placed in the maxillary anterior region, while 33% of the restored teeth were maxillary or mandibular premolars. In 68.6% of patients, the natural dentition formed the antagonistic arch; 28.5% of patients had a fixed partial denture.

Table 1 shows the number of full crowns placed per patient, the number of failed or survived restorations within the patient, and the frequency distribution in the study population. Eight patients lost 27 of a total of 116 failing full crowns, which is 23.3% of the total failure rate. The reasons for failure in this group of 8 patients were biologic (74.1%) and mechanical (25.9%). Out of the whole group of 456 patients, only 86 patients (18.9%) had one or more irreversible failures.

The past caries sensitivity of the whole patient group is shown in Fig 1 and revealed a rather caries-sensitive population. The study population was divided into a caries-nonsensitive group (group 1, 27.6%), a moderately sensitive group (group 2, 18.6%), and a caries-sensitive group (group 3, 53.8%).

The reasons for removal of the full crown or tooth (irreversible complication) were caries (24.3%), periodontal problems (17.2%), fracture of the abutment tooth (12.9%), and endodontic problems (12.0%). These are all biologic factors and accounted for 66.4% of the irreversible complications. Technical and patient-related failures, such as fracture of porcelain (8.7%), loss of retention (6.0%), fracture of the post (4.3%), teeth needed as abutment for a fixed partial restoration (11.2%), and trauma (1.7%), represented 31.9% of losses. In 1.7% of cases, the reason for failure was unknown. These results are in contrast with the reversible complications: in this group, 83% of the failures were technical problems, such as loss of retention (69%) or fracture of porcelain (14%). Caries and endodontic problems were the cause of 17% of the reversible complications.

Table 2 is a cross-tabulation of surviving restorations versus failed restorations, with reversible complication as dependent variable. In the group of the surviving restorations, only 4.7% experienced a reversible complication, which means that there was loss of retention and/or caries or pulpal problems, but the full crown was able to be recemented without failure of the abutment tooth, the preparation margin, or the full crown. In the group of the failing restorations, 19.0% experienced a reversible complication. Occurrence of a previous reversible complication seems to have a predictive value for irreversible complication later on; the difference was highly statistically significant (log-rank test; $P = .001$). In the group of failing restorations, reversible complications occurred early after cementation (within 2 years) or later (after more than 2 years). The mean survival time for the early-reversible-complication-group was 1.5 years, while the mean survival rate for the late-reversible-complication-group was 8.4 years. This is a statistically significant difference ($P = .009$).

The Kaplan-Meier survival curves for all restorations, in the maxilla and mandible, are shown in Fig 2. There was no statistically significant difference between the maxilla and mandible after 18 years ($P = .150$), with 78.1% and 78.2% survival, respectively. The survival rates after 6 years were 94.1% (maxilla) and 97.3% (mandible), and after 12 years they were 83.8% (maxilla) and 88.2% (mandible).

Figure 3 shows the Kaplan-Meier survival curves for molar, premolar, and anterior teeth restorations. After 18 years, the survival rates were 80.3% for the molars, 78.6% for the premolars, and 76.1% for the anterior teeth. The differences between groups were not statistically significant ($P = .671$). The survival rates after 6 years were 96.1% (molars), 95.7% (premolars), and 93.9% (anteriors), and after 12 years they were 86.4% (molars), 86.6% (premolars), and 83.1% (anteriors).

Table 2 Cross-Tabulation of Surviving Restorations Versus Failed Restorations, with Reversible Complication as Dependent Variable ($P = .001$)

	Reversible complication		
Irreversible complication	No (%)	Yes (%)	Total (%)
No	877 (95.3)	43 (4.7)	920 (100)
Yes	94 (81.0)	22 (19.0)	116 (100)

A comparison of the survival rates (after 18 years) on the different types of teeth showed no statistically significant difference ($P = .850$). No distinction was made between the maxillary and mandibular teeth. The survival rate of the incisors was 88.9%, for the canines it was 85.5%, for the premolars it was 88.8%, and the molars had a survival rate of 89.4%.

Figure 4 shows the survival curves for post-and-core crowns compared to the full crowns without posts and cores; their survival rates were 79.4% and 74.9%, respectively after 18 years. The difference between the 2 groups was not statistically significant ($P = .602$). The survival rates after 6 years were 95.2% (posts and cores) and 93.9%, and after 12 years they were 84.7% (posts and cores) and 85.6%.

The oral hygiene of the patients (PI) and their periodontal conditions (BOP) were recorded during this study. The mean PI and BOP at cementation for the surviving restorations were 33.6% and 22.2%, respectively. For the failing restorations the mean PI was 36.0% and the BOP was 24.4%.

The Wilcoxon test revealed that the PI ($n = 37$, $P = .831$) and BOP ($n = 37$, $P = .276$) at the time of cementation were not statistically significantly correlated to the occurrence of failure. For the surviving restorations the PI ($n = 593$, $P = .001$) was statistically significantly correlated, but the BOP ($n = 600$, $P = .654$) was not.

Discussion

In the dental literature, studies of the lifespan of fixed prosthetic restorations are divided into short-term and long-term clinical evaluations. In comparison to other topics in the prosthetic field, which have been extensively studied in vitro and in vivo, long-term survival studies of fixed prostheses are scarce.[21] In the last decade, on the other hand, studies dealing with the short-term survival of fixed prostheses on dental im-

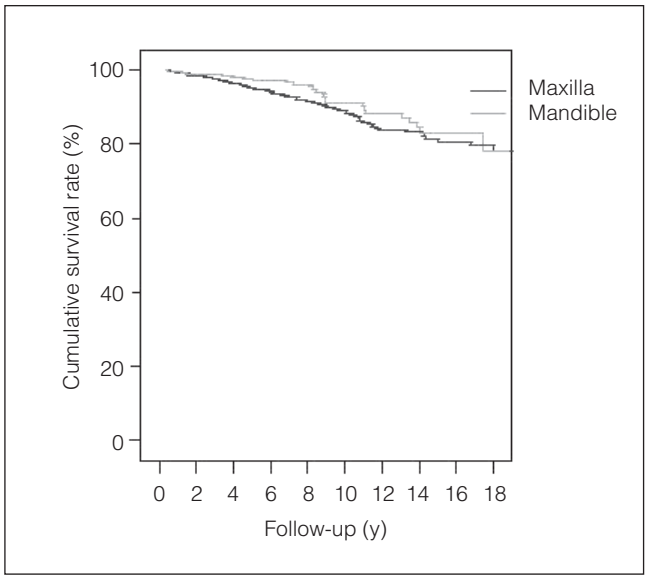

Fig 2 Kaplan-Meier survival curves for all restorations in the maxilla and the mandible ($P = .150$).

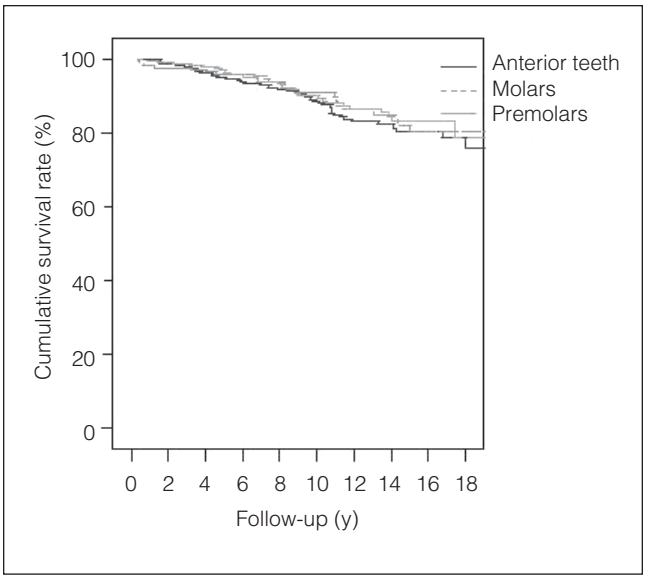

Fig 3 Kaplan-Meier survival curves for restorations on molars, premolars, and anterior teeth ($P = .671$).

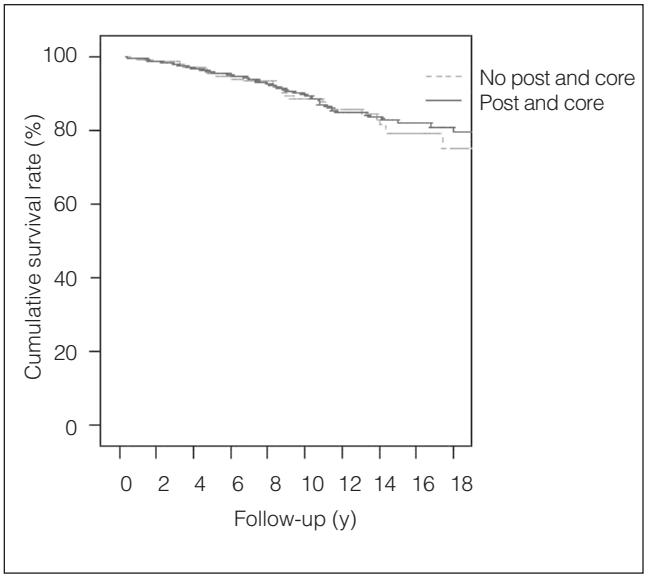

Fig 4 Kaplan-Meier survival curves for full crowns with and without posts and cores (P = .602).

plants have been widely documented.[22] Nevertheless, the treatment option of fixed prosthetic work on natural teeth still forms an important part of the work of general practitioners and prosthodontists. Some authors have published retrospective studies on the survival of fixed partial dentures for different periods of time, up to 22 years of service.[9,13,17,23] However, on the survival of full crowns only one paper has been published on different points of time, up to 15 years.[24] The present study made estimations on the survival after 6, 12, and 18 years of service.

The overall survival rate of 78.1% after 18 years is high. This positive result could be even higher if those "lost" full crowns that were used as abutments for fixed partial dentures (11%) had been considered surviving. The status of the dentition in the opposing jaw of the full crown were a natural dentition in 68.6% of subjects and a fixed partial denture in 28.5% of patients. In 97.1% of the patients, there were no diminished occlusive forces as there would be for full removable dentures.

In this study the practitioners were undergraduate students in an university clinic. Comparing their results to those of other studies, with general practitioners, one can conclude that at least there are no differences in the survival rates.[24,25]

In the study of Leempoel,[25] the survival rate after 12 years ranged from 78% to 94%. In the present study, there is a comparable range, from 83.5% to 87.7%. Valderhaug[23] and Sundh and Ödman[17] concluded from their studies that in general, there is no reason to believe there would be any major difference in the clinical performances of practitioners and undergraduate students; at least, the type of practitioner seems not to influence the longevity of the construction in a substantial way. Holm et al[26] concluded that the operators' lack of completed training was not likely to be a disadvantage, because there were extensive treatment plans and the treatments were closely supervised.

Root canal–treated teeth with a post-and-core crown represented 79.2% of the study group. This percentage

reflects a high past caries sensitivity of this study group (groups 2 and 3, 72.4%). Three of the most common reasons for full crown preparation were extensive loss of crown substance owing to caries (65.9%), trauma (7.7%), and endodontic problems (6.3%)—all problems that generally necessitate a root canal treatment and/or a post-and-core full crown.

All post-and-core restorations were cast gold posts fused with the full crowns, thus avoiding a second cement interface, as in a cast post and core disconnected from the full cast crown. The restorations, on vital and on root canal–treated teeth, were all placed under the same conditions and a zinc phosphate cement was used.

After 18 years of service, the survival rates for post-and-core crowns and full crowns without post and core were 79.4% and 74.9%, respectively. There was no statistically significant difference between both types of restorations, which contradicts the results of Leempoel.[25] The effectiveness and durability of post-and-core crowns have been questioned in many studies,[15,17,25,27] and speculations on the probable causes of increased rate of failure were offered.[17,27] However, Palmqvist and Swartz[28] concluded that a root canal–treated abutment tooth should not be considered to have an increased risk for failure. In a study that assessed the periapical and clinical status of crowned teeth over a 25-year period, Valderhaug et al[16] observed that crowned, root canal–filled teeth with a high-quality endodontic treatment had a similar survival rate as crowned teeth with a vital pulp. This present study confirms that the custom-cast post-and-core full crown is not necessarily the weakest part of a prosthetic treatment. However, a recent study confirmed that custom-cast posts are preferable to prefabricated fiber-reinforced composite (FRC) posts for restoring single-rooted teeth, but prefabricated FRC posts were preferred to ceramic posts because of their high fracture resistance.[29]

Caries, periodontal problems, fracture of the abutment tooth, and endodontic problems—all factors of biologic origin—were the reasons for 66% of the removals. Several authors found caries development to be the most frequent complication in fixed prosthetic restorations.[17,30–32] In this study, caries (24%) was also the primary factor for failure. Loss of retention, a factor that is frequently combined with caries, occurred in 6%. Most striking is the fact that the four most frequent reasons for failures were of biologic origin. Valderhaug[23] and Sundh and Ödman[17] found similar results.

In the present study, failure was divided into 2 groups: irreversible complications and reversible complications. A full crown could have a previous reversible complication followed in time by an irreversible complication (failure). The occurrence of a previously reversible complication seems to have a predictive value for an irreversible complication later on. The mean survival time of the early ($<$ 2 years) reversible-complication group was 1.5 years, while the mean survival time of the late ($>$ 2 years) reversible-complication group was 8.4 years. To our knowledge this has not yet been published in another survival study but is confirmed by the same authors in a survival study of fixed partial dentures.[33]

The second most frequent reason for failure was periodontal problems. In the present study we focused on periodontal variables using plaque scores, BOP, and the CPITN with a full-mouth assessment. These results are detailed elsewhere (De Backer et al, unpublished data). PI and BOP, at baseline, are not good predictors for survival. These variables, indicating the level of oral hygiene and gingival health at baseline, are not an adequate reflection of the biologic and periodontal mechanisms involved on a long-term basis in the survival of full crowns.

Conclusion

The survival of full crowns, fabricated by undergraduate students at a university clinic, over an 18-year period was 78.1%. This result is comparable to the results of other studies and to the results of studies performed by general practitioners. There were no statistically significant differences in the survival between restorations in the maxilla and the mandible; between full crowns on molars, premolars, and anterior teeth; and between post-and-core crowns and full crowns on vital abutment teeth. Caries was the most common reason for failure, followed by periodontal problems. Biologic reasons for removal (66%) were more common than technical failures. The most frequent technical reasons for failures were fracture of porcelain and loss of retention. Occurrence of a previous reversible complication seemed to have a predictive value for the irreversible complication later on. A reversible complication within the first 2 years after cementation will probably lead to an early irreversible complication.

Acknowledgments

The authors are very thankful to Frank Herrebout and Veerle Decock, former Assistant Professors from the former Department of Fixed Prosthodontics and Periodontology, Dental School, Faculty of Medicine and Health Sciences, Ghent University, Belgium for their valuable help.

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