

Long-term survivals of 'direct-wax' cast gold onlays: a retrospective study in a general dental practice

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IN BRIEF

- A retrospective longevity study performed at a mixed general practice.
- The first study that provides evidence about the direct wax technique for indirect restorations.
- The proposed technique is highly successful in a general practice environment.

Background and objectives Compared to other restoration types, indirect cast posterior restorations of partial coverage exhibit one of the longest survivals. The purpose of the current study was to estimate the success rates of 'direct-wax' cast gold onlays. According to the direct wax technique, the wax pattern is shaped intra-orally followed by direct casting without the need for impressions, resulting in low cost and short processing time. **Design and methods** A retrospective survival study was undertaken at a mixed National Health Service and private general dental practice based in London. Patients with direct-wax onlays attending over a period of four months for regular check-ups or dental treatment were recruited. Patient discomfort, pain or sensitivity was recorded. Restoration location, extension, marginal fit, and tooth vitality were also recorded. Restoration failure was defined in the event of recurrent caries, pulp infection for vital teeth, increase in the size of periapical radiolucency for non-vital teeth, and restoration decementation. Survival estimates were calculated using the Kaplan-Meier algorithm. **Result** One hundred and ninety-four onlays in 56 patients were examined. Four restorations (2.1%) had failed, mainly due to recurrent caries. The cumulative survival probability was estimated at 415.3 (95% Confidence Interval: 403.0, 427.7) months (34.6, 95% CI: 33.6, 35.6 years), while the 10-year and 20-year survival rates were 97.0% and 94.1% respectively. Vital teeth, compared to non-vital ones, and onlay extension encompassing both the mesial and distal tooth surfaces exhibited significantly ($P < 0.05$) higher success rates. Variations in marginal fit and restoration location did not affect the survival probability. **Conclusion** Direct-wax cast gold restorations of partial coverage were a highly successful treatment option for posterior restorations in a general dental practice environment.

INTRODUCTION

It is well established that full coverage indirect restorations comprise the most durable mode of restoration for posterior teeth.¹ A recent meta-analysis study demonstrated a 5-year survival rate of 95.6% for metal-ceramic full crowns.² Other conventional longevity studies have reported that the 10-year survival rates for indirect single crown restorations range between 75% and 85%.³⁻⁵

The destructive nature of full crown restorations can be avoided with the implementation of more conservative restorations in the form of partial crowns and onlays. Longevity studies have again

established a high success rate for these types of conservative restorations ranging between 85 and 95% over a 10-year period.^{6,7} The superior performance of indirect full-coverage crowns over large direct amalgam restorations has also been established.⁸

All published studies concerning the provision of cast onlays and partial crowns invariably involve an impression step, by which the tooth preparation is transferred to the laboratory. Therefore, the construction of the restoration demands pouring of stone model, indirect waxing-up, spruing and casting. An alternative 'direct-wax' technique involves shaping of the wax-pattern directly on the patient's tooth, which is then sprued and cast. The obvious advantages of this method include reduced cost and time, since the impression, casting and waxing steps can be omitted. The main disadvantage of this technique is related to the skill of the operator to provide the appropriate morphology intra-orally.

A PubMed search failed to locate any publications about direct-wax cast restorations. The purpose of this study is to retrospectively evaluate the quality and longevity of direct-wax partial-coverage cast restorations provided as a routine treatment in a UK-based mixed National Health Service (NHS) and private general dental practice.

DESIGN AND METHODS

Type of study

This retrospective analysis was performed at a general dental practice based in London, UK providing mixed NHS and private service. All patients, having been provided with direct-wax cast gold restorations in the past, attending for regular 6-month check-ups or any further treatment over a period of four consecutive months (between January and April 2008) were included in this study. This period was randomly selected with the only restriction

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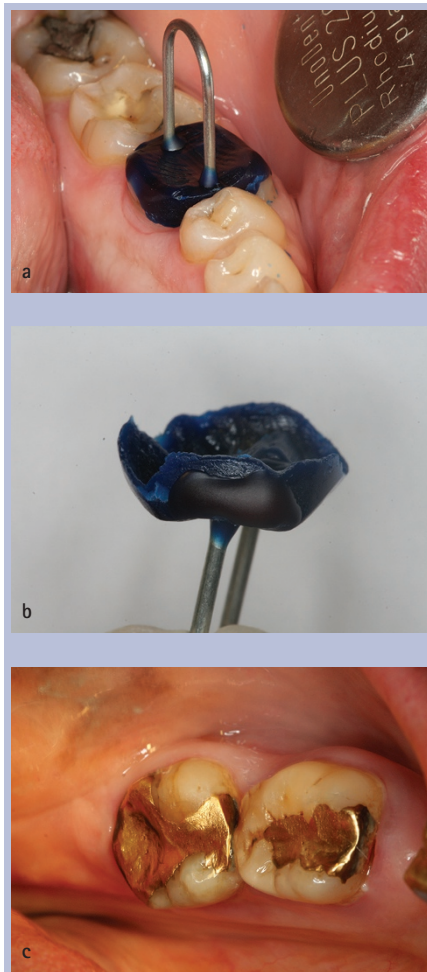


Fig. 1 Representative photographs of the direct-wax cast gold inlay making process a) A typical wax pattern with the paper-clip attached intra-orally b) The same wax pattern removed and ready for spruing and casting c) Photograph of two gold onlays, lower left 8 is 31 years old and lower left 7 is twenty years old

being the inclusion of one major holiday period. Restorations less than 12 months old were not recorded.

Treatment procedure

The patient selection criteria for cast gold restorations included cuspal fracture and/or an isthmus width more than 1/2 of the tooth width,⁹ provided that the patients could maintain a satisfactory oral hygiene level and a controlled sugar intake.

Preparation was performed with high-speed handpieces. Proximal boxes were prepared, while all other margins were finished as chamfer or feather-edge on sound tooth structure.

A matrix band was fitted tightly around the prepared tooth. A softened type 2 casting wax (Blue inlay casting wax, KerrHawe, Bioggio, Switzerland) was packed into the

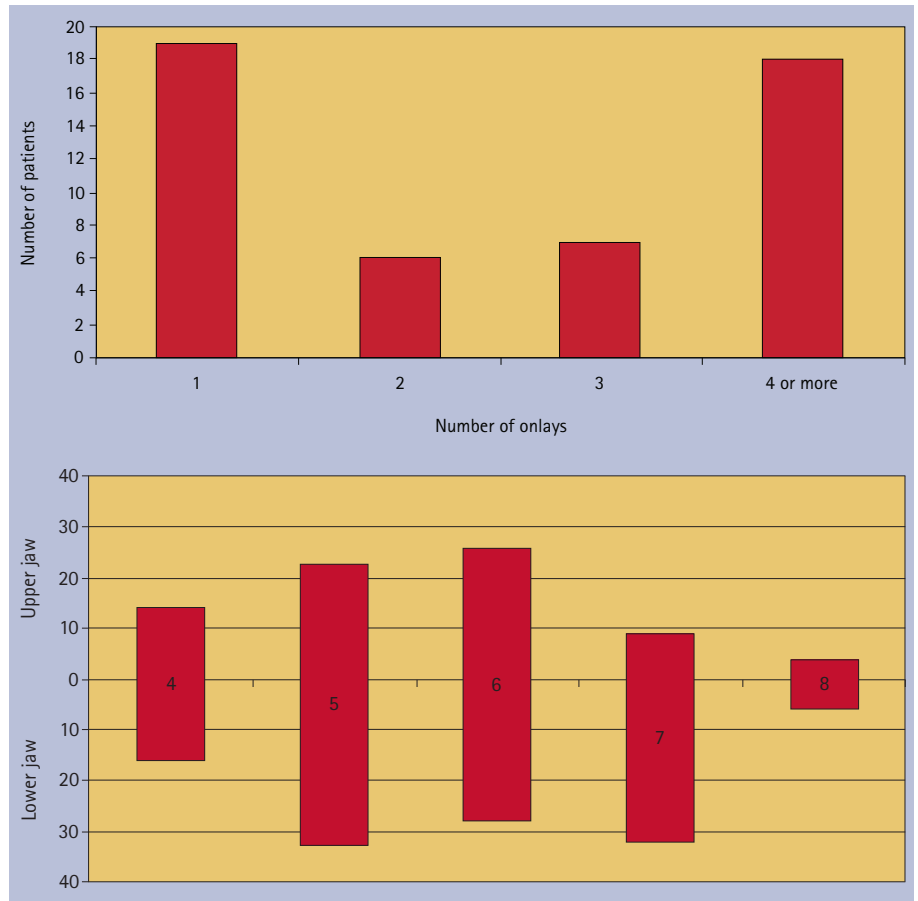


Fig. 2 Explanatory charts showing the distribution of onlays a) Distribution of onlays among patients b) Distribution of onlay location (4: 1st premolar, 5: 2nd premolar, 6: 1st molar, 7: 2nd molar, 8: 3rd molar)

matrix band, allowed to cool and then carved. Final adjustment of the margins and the occlusal surface was done after the matrix band was removed. The wax model was removed from the preparation with the help of a warm paper clip. Contact areas were then bulked up and the wax allowed to cool at room temperature (Fig. 1).

Sprues were attached to the wax model and then invested in a type 1 gypsum-bonded investment material. Casting was performed using a type 2 gold alloy (Mattident G, Primus Sud Edelmetallvertrieb GmbH, Rosenheim, Germany). After casting, the sprues were removed, while final occlusal, interproximal adjustments and polishing were done chairside.

The restorations were cemented at the day of the preparation using a Zinc Phosphate cement (De Trey Zinc, Dentsply Limited, Addlestone, UK). During cementation the patients were instructed to bite on orange-wood sticks. Finally, the margins were burnished.

The clinical procedure for every patient was performed by one operator (LKB).

Data collection

Patient consent was obtained following current legal legislation in the UK following the Primary Care Trusts (PCT) guidelines. The patient details recorded included gender and date of birth.

The restoration details recorded included cementation date, restoration type (proximal extension), tooth location, tooth vitality and the presence of a post and core for non-vital teeth. All restorations were designed to have cuspal coverage. If both mesial and distal boxes were prepared, the restorations were classified as MOD; if only the mesial or distal box was prepared, the restorations were classified as either MO or DO respectively. The extent of buccal or palatal/lingual extension was not recorded.

Patients were asked to evaluate each restoration. The details recorded included pain, sensitivity to hot, cold, sweet or bite, and discomfort from morphological and functional aspects.

The evaluation of the restorations was performed by clinical (direct vision and/

or examination probe) and radiographic examination when available. The details recorded included deficient (presence of marginal gap) or overhanging margins, tooth fracture, restoration fracture, restoration decementation, recurrent (secondary) caries, and pulp necrosis for vital teeth or unsuccessful endodontic treatment for non-vital ones.

Failure of the restoration was defined in the cases of tooth fracture, restoration fracture, restoration decementation, recurrent caries, loss of vitality for vital teeth, unsuccessful endodontic outcome for non-vital teeth and need for extraction other than periodontal reasons or accident. Longevity was expressed in months from the date of cementation to the date of patient examination.

Calibration of examiners

The evaluation of the restorations was performed by two operators (LKB and GM). Twenty-five percent of the patient pool was examined in the presence of both authors to set the evaluation criteria. The level of agreement between the two examiners of the study was tested using weighted Kappa-test (0.768).

Statistical analysis

Survival analysis was performed using the Statistical Package for Social Sciences (version 13.0.1, SPSS Inc, Chicago, Illinois, USA). The Kaplan Meier technique, including tables and graphical data presentation, was employed as the most appropriate technique to analyse censored data by calculating survival probabilities. The log-rank non-parametric test was used for testing the null hypothesis that the variables under investigation are from samples of the same population regarding their survival experience. The level of statistical significance was set at 0.05.

RESULTS

Within the selected period of four months, 56 patients with a total of 194 direct wax onlays were examined. None of the patients refused to participate to the study. 57.7% of the patients were female. Mean age was 56.2 ± 11.8 years. The distribution of onlays among the patients is presented in Figure 2a. The distribution of onlays among the posterior teeth of the upper and lower jaws is presented in Figure 2b.

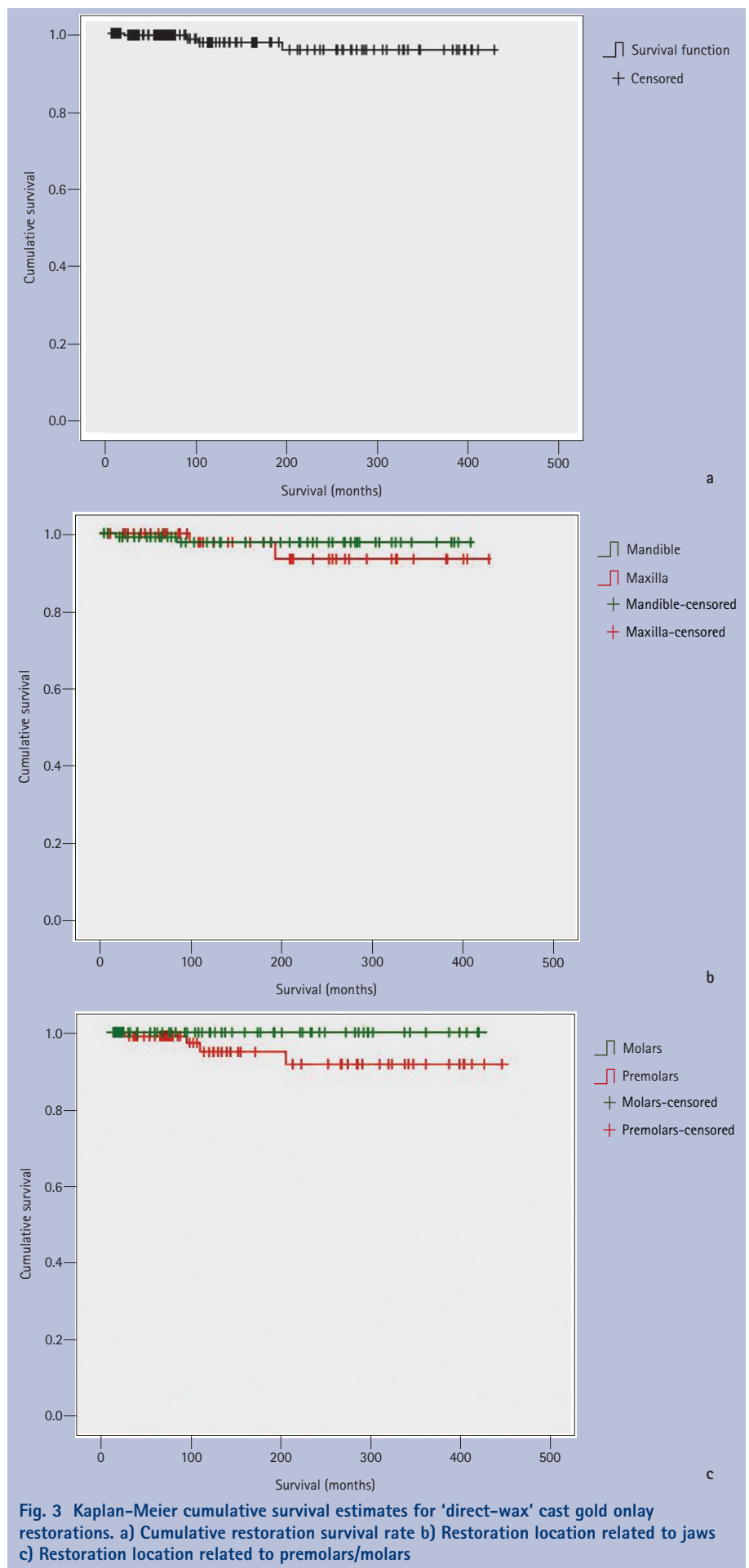


Fig. 3 Kaplan-Meier cumulative survival estimates for 'direct-wax' cast gold onlay restorations. a) Cumulative restoration survival rate b) Restoration location related to jaws c) Restoration location related to premolars/molars

None of the patients complained of pain, sensitivity or discomfort.

The majority of onlays exhibited mesial and distal proximal extensions (94.3%), while 2.6% and 3.1% had mesial or distal only extensions respectively. Also the majority of onlays were placed on vital teeth (83.5%). Of the non-vital teeth, 40.6% had a post. The majority of onlays exhibited good margins (83.5%); 11.3% exhibited deficient, while 5.2% had overhanging ones.

Of the observed restorations, only four failures were recorded (2.1%). Three failures were due to recurrent caries, while one was attributed to an increased periapical radiolucency associated with a root treated tooth. Interestingly, two of the failures due to caries were observed on the same patient.

The observation time ranged from 12 to 428 months (1 to 35.7 years). The Kaplan-Meier cumulative survival probability was estimated at 415.3 (95% Confidence Interval: 403.0, 427.7) months (34.6 years; Fig. 3a). The 10-year and 20-year survival rates were 97.0% and 94.4% respectively. No statistically significant difference was found for restoration location either between the upper and lower jaws [410.4 (34.2 years; 95% CI: 386.5, 434.4) *vs.* 400.0 (33.3 years; 95% CI: 387.4, 412.5) months respectively; Fig. 3b], or between premolars and molars [415.3 (34.6 years; 95% CI: 403.0, 427.7) months for both cases; Fig. 3c]. Restorations with mesial or distal proximal extensions only exhibited significantly worse longevity [265.4 (22.1 years; 95% CI: 216.2, 314.5) months] compared to combined mesial and distal extensions [421.9 (35.1 years; 95% CI: 413.4, 430.4) months; $P = 0.002$; Fig. 3d]. Non-vital teeth also exhibited a lower survival rate [298.2 (95% CI: 258.2, 338.1) months] compared to vital ones [420.9 (35.1 years; 95% CI: 411.0, 430.8) months; $P = 0.023$; Fig. 3e]. Finally, no statistically significant differences were found related to the presence of unsatisfactory, either deficient or overhanging, margins [416.6 (34.7 years; 95% CI: 403.7, 429.5) months *vs.* 366.6 (30.5 years; 95% CI: 337.3, 395.9) months; Figure 3f.

DISCUSSION

The superior longevity of indirect cast gold restorations is well established compared

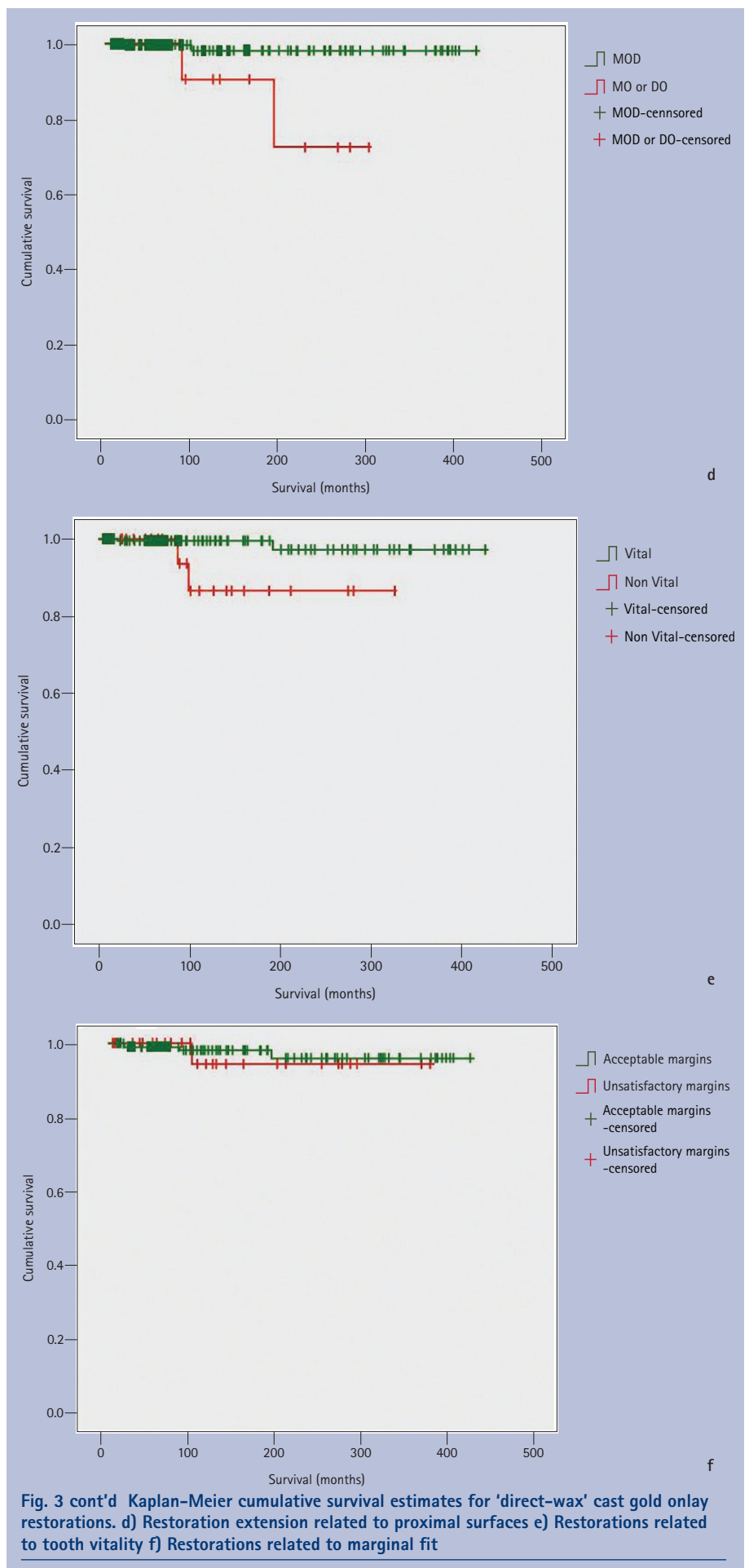


Fig. 3 cont'd Kaplan-Meier cumulative survival estimates for 'direct-wax' cast gold onlay restorations. d) Restoration extension related to proximal surfaces e) Restorations related to tooth vitality f) Restorations related to marginal fit

to any other kind of dental restorations.¹ The purpose of the current study was to assess whether the 'direct-wax' technique renders comparable longevity estimates to the traditional indirect method that involves impression taking.

The study was designed in an effort to minimise patient selection bias. For this reason an observation period of four randomly selected months including one major holiday period was set. No recall procedure was involved and only patients that presented for regular check-ups or were undergoing treatment were included in the study. Interestingly, none of the patients refused to take part into the study. Another strong point of this study is the fact that treatment was provided in a mixed NHS and private general practice based in London, while the majority of previous publications have been performed under hospital, university or specialised practice environments.

On the other hand, this study being retrospective in nature is inherently weakened, as patient sample could be randomised. Moreover, the limited resources in a general dental practice restrict the length and extent of the study; an extended recall procedure that would include non-regular attendees was not feasible. Also the fact that all restorations were placed by only one dentist indicates that the results cannot be extrapolated to a broad spectrum of general dentists.

Most importantly, the longevity of the direct wax cast gold onlays in our study, with 10-year and 20-year survival rates of 97.0% and 94.1% respectively, is comparable to reported longevity figures of traditional indirect restorations with partial coverage. Previously reported 10-year survival rates include 96.1%,⁷ 94.5%,¹⁰ 86.1%,⁶ 72.9%¹¹ and 40.8%.¹² The low survival rates in the study by Smales & Hawthorne¹¹ could be attributed to the possible high inclusion of inlays, as their relative percentage is unclear, while the small sample size (22 gold castings) in the study by Kelly and Smales¹² may distort the true longevity values. Further publications that have not, however, implemented a statistical longevity procedure are also available.

Mjor and Medina reported a median age of 15 years for gold castings, without clarifying the onlay percentage,¹³ while Jokstad *et al.* also reported a median age of 20 years in a mixed sample of gold onlays, inlays and crowns.¹⁴ Finally, Donovan *et al.* reported a failure rate of 3.0% over 197 onlays.¹⁵ Moreover, the majority of failures are due to recurrent caries, which agrees with existing studies.^{6,7}

An area of great concern is marginal fit. By implementing the direct wax technique, possible errors during the impression and pouring stages are eliminated, while margin determination of ambiguous areas does not rely on the technician's abilities. Moreover, the use of orange-wood sticks by the patient during cementation of type 2 gold alloy castings effectively adapts the restoration to the margins of the preparation. In support of this statement, a low percentage of unsatisfactory margins (16.5%) was found in our study, which included 11.3% deficient and 5.2% overhanging margins. Schwartz *et al.*³ and Walton *et al.*⁴ reported the presence of deficient margins for full-coverage crowns at percentages of 11.3% and 10.4% respectively.

An interesting observation involves the worse performance of mesial or distal only proximal extensions compared to combined mesio-occluso-distal ones. Although previous studies have not addressed this variable, this phenomenon can possibly be attributed to the inferior retention of the partially extended onlays.

Moreover, vital teeth exhibited higher survival probabilities compared to root-treated ones, which agrees with the study by Studer *et al.*⁷ The most plausible reason involves the weakened tooth structure remaining following deep cavities that affect pulp status and the endodontic procedures required for proper access.⁹

As far as the location of the restorations is concerned, no differences in survival were demonstrated either between the upper and lower jaw, or between premolars and molars, which is in accordance with previous studies.^{6,7}

Finally, the presence of either deficient or overhanging margins did not have an

adverse effect on restoration survival.¹³ Factors related individually to patients, such as oral hygiene, sugar consumption and parafunction, were probably more important.

In conclusion, direct-wax cast gold restorations of partial coverage were very successful and predictable in a general practice environment. The operator must take into consideration that partially extended at the proximal areas onlays and non-vital teeth exhibit worse clinical performance.

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1. Manhart J, Chen H, Hamm G, Hickel R. Buonocore Memorial Lecture. Review of the clinical survival of direct and indirect restorations in posterior teeth of the permanent dentition. *Oper Dent* 2004; **29**: 481–508.
2. Pjetursson B E, Sailer I, Zwahlen M, Hämmerle C H. A systematic review of the survival and complication rates of all-ceramic and metal-ceramic reconstructions after an observation period of at least 3 years. Part I: Single crowns. *Clin Oral Implants Res* 2007; **18**: 73–85.
3. Schwartz N L, Whitsett L D, Berry T G, Stewart J L. Unserviceable crowns and fixed partial dentures: life-span and causes for loss of serviceability. *J Am Dent Assoc* 1970; **81**: 1395–401.
4. Walton J N, Gardner F M, Agar J R. A survey of crown and fixed partial denture failures: length of service and reasons for replacement. *J Prosthet Dent* 1986; **56**: 416–421.
5. Cheung G S. A preliminary investigation into the longevity and causes of failure of single unit extra-coronal restorations. *J Dent* 1991; **19**: 160–163.
6. Stoll R, Sieweke M, Pieper K, Stachniss V, Schulte A. Longevity of cast gold inlays and partial crowns – a retrospective study at a dental school clinic. *Clin Oral Investig* 1999; **3**: 100–104.
7. Studer S P, Wettstein F, Lehner C, Zullo T G, Schärer P. Long-term survival estimates of cast gold inlays and onlays with their analysis of failures. *J Oral Rehabil* 2000; **27**: 461–472.
8. Smales R J, Hawthorne W S. Long-term survival of extensive amalgams and posterior crowns. *J Dent* 1997; **25**: 225–227.
9. Reeh E S, Messer H H, Douglas W H. Reduction in tooth stiffness as a result of endodontic and restorative procedures. *J Endod* 1989; **15**: 512–516.
10. Bentley C, Drake C W. Longevity of restorations in a dental school clinic. *J Dent Educ* 1986; **50**: 594–600.
11. Smales R J, Hawthorne W S. Long-term survival of repaired amalgams, recemented crowns and gold castings. *Oper Dent* 2004; **29**: 249–253.
12. Kelly P G, Smales R J. Long-term cost-effectiveness of single indirect restorations in selected dental practices. *Br Dent J* 2004; **196**: 639–643.
13. Mjor I A, Medina J E. Reasons for placement, replacement, and age of gold restorations in selected practices. *Oper Dent* 1993; **18**: 82–87.
14. Jokstad A, Mjor I A, Qvist V. The age of restorations in situ. *Acta Odontol Scand* 1994; **52**: 234–242.
15. Donovan T, Simonsen R J, Guertin G, Tucker R V. Retrospective clinical evaluation of 1,314 cast fold restorations in service from 1 to 52 years. *J Esthet Restor Dent* 2004; **16**: 194–204.