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In vitro cavity and crown preparations and direct restorations carried out by Foundation Dentists (FDs) in the Oxford and Wessex Deaneries: A comparison of performance at the start and end of the FD programme.

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Abstract

Aim:

To assess the performance and thereby the progress of the FDs when they carried out a number of simulated clinical exercises at the start and at the end of their FD year.

Methods:

A standardised simulated clinical restorative dentistry training exercise was carried out by a group of 62 recently qualified dental graduates undertaking a 12 months' duration foundation training programme in England, at both the start and end of the programme. Participants completed a Class II cavity preparation and amalgam restoration, a Class IV composite resin restoration and two preparations for a porcelain-metal full crown. The completed preparations and restorations were independently assessed by an experienced consultant in restorative dentistry, using a scoring system based on previously validated criteria. The data were subjected to statistical analysis.

Results:

There was wide variation in individual performance. Overall, there was a small but not statistically significant improvement in performance by the end of the programme. A statistically significant improvement was observed for the amalgam preparation and restoration, and, overall, for one of the five geographical sub-groups in the study. Possible reasons for the variable performance and improvement are discussed as is the potential for a similar exercise to be used as part of summative assessment of the programme.

Conclusions:

There was variability in the performance of the FDs. The operative performance of FDs at the commencement and end of their FD year indicated an overall moderately improved performance over the year and a statistically significant improvement in their performance with regard to amalgam restoration.

Introduction

The purpose of dental foundation training is defined in the NHS Performers List Regulations (England)[1] as a relevant period of employment during which a dental practitioner is employed under a contract of service by an approved trainer to provide a wide range of dental care and treatment, with the aims and objectives being the enhancement of clinical and administrative competence and promoting high standards through relevant postgraduate training.

Foundation Dentists (FDs) are predominately recent graduates of UK dental schools, with training programmes being designed to meet the requirements of the UK Dental Foundation Training Curriculum[2]. On completion of a year's training the dentist is awarded a Foundation Training Certificate by a Postgraduate Dental Dean or Director, allowing the dentist to perform NHS primary care dental services without supervision.

Prior to graduation, the FDs will have completed a variable number of direct and indirect restorations, based on the syllabus set by their different universities of graduation, but which also must be sufficient to satisfy the curriculum published by the Regulatory Body, the UK General Dental Council[3] . As described in a previous paper[4] it was considered by the Oxford and Wessex Deaneries that the FDs would benefit from undertaking a day-long basic restorative dentistry "refresher course" on phantom head models as soon as possible after entering the dental foundation training programme. Their performance on this course was externally reviewed, in order to inform a preliminary assessment of the FDs' individual learning needs, so that any areas identified for improvement could be targeted by their educational supervisors (trainers). This activity was subjected to an audit, across all five training

schemes, the results of which have previously been published[3], indicating variation in performance.

The volume of treatment carried out by FDs when in their practices is likely to substantially exceed the volume of treatment which they carried out in dental school, given that they will become familiar with their own surgery and be assured of nursing assistance, and also since they are expected to work clinically for at least 28 hours per week and meet minimum clinical activity requirements.. However, a question which is relevant to the third party funders of the FDs' training, the FD trainers (now termed Education Supervisors), and their patients, is – *does the FD training equate to an improved clinical performance*? No data are available on this subject. It is therefore the aim of this study to assess the performance and thereby the progress of the FDs when they carried out a number of simulated clinical exercises at the start and at the end of their FD year (this term being used throughout the paper to indicate the 12-month period in which the FDs are in training).

Methods

The operative training exercises

The methodology utilised for assessing the FDs' performance with regard to cavity/crown preparation and two restorations has previously been described[4]. However, in brief:

- All preparations and restorations were carried out on standard plastic teeth (Kavo model teeth with numbered roots) mounted in a full arch in phantom heads in a purpose built unit to simulate a normal clinical operating position.

- The FDs were asked to prepare a disto-occlusal class II cavity in tooth LL6, with the cavity size being appropriate to the radiograph which they had been shown and the cavity design being appropriate for an amalgam restoration.

- The FDs then were asked to repeat the exercise on the LR6 and then use their “normal” technique to restore the cavity with amalgam.

- The FDs were asked to restore a standardised pre-cut class IV cavity in UL1 with resin composite.

- The FDs were asked to prepare two teeth for porcelain fused to metal (PFM) crown preparations, UL4 and UR4, having previously viewed a PowerPoint presentation prepared by one of the authors (LM) in which they were given standardised instructions, based upon well recognised contemporary texts on crown preparation, such as Shillingburg[5]. For one of these preparations, the FDs used a putty matrix, although, in the previous study, this had no influence on the grade achieved[4]. For the other preparation, a putty matrix was not utilised. The FDs were left to determine the shoulder thickness appropriate for the specified materials and were left to judge the depth of the preparation, as part of the exercise.

The FDs in the cohort who are the subject of this study were undertaking dental foundation training from 1st August 2013 until 31st July 2014.

The start of year exercises were carried out during August 2013, and the second group of exercises (hitherto termed end of year) carried out in May 2014.

The Audit

A scoring system was devised by one of the authors (LM, an experienced teacher in the “phantom head” environment), based upon generally-considered criteria for an ideal amalgam class II cavity, an anatomically satisfactory class IV resin composite restoration and a satisfactory PFM crown preparation[4] (Table 1). When the FDs had completed their preparation and restoration exercises, the models were collected and sent to a regional Dental Postgraduate Centre where one calibrated examiner who is an experienced teacher and Consultant in Restorative Dentistry, (FJTB) assessed the restorations using the scoring system and modified USPHS/Ryge criteria[6]. These criteria typically include grades for colour match, cavo-surface discolouration, secondary caries, anatomic form and marginal adaptation. However, because of the need to use plastic models for which there will necessarily be a suboptimal shade match, neither shade match, caries or marginal discolouration could be assessed and, therefore, only anatomic form and marginal adaptation were considered.

The original marks scheme (Table 1) was designed to award a score of 1 for aspects of an optimum preparation or restoration, 2 for a clinically acceptable preparation or restoration (but with one or more errors) and/or restoration and 3 for a suboptimal preparation/restoration. Hence the minimum overall score for all 3 restorations which could be awarded was 35, with the maximum being 105.

Statistical analysis

In order to facilitate data analysis, the original marks scheme was recoded. When recoded, the lowest score (previously the highest numerical mark) was recoded as zero, an intermediate performance as 1, while the optimum performance (previously

the lowest numerical mark) was recoded to a score of 2. Depending on marking criteria, the range of marks for each domain varied. The total mark was calculated by adding the marks for each domain (Table 2). Descriptive statistics were calculated in order to compare the marks from August 2013 and those of May 2014. In order to determine the appropriate statistical test for difference, we tested the normality of the data using both Q plots and Shapiro–Wilk test. Due to non-normal distribution of the data, using parametric tests was found inappropriate. Mann Whitney U test were employed to examine differences between the first and second set of exercises. The recoded scores (where the maximum possible for optimal performance is 78) will be used for the remainder of this paper.

Results

In August 2013, 62 dental trainees took part in the exercise, whereas data are available for only 61 trainees in May 2014, because one trainee did not attend for the second exercise. For one of these FDs, two prepared teeth were not submitted for assessment, thought to be due to the loss of these teeth in transit to the regional assessment centre. For practical reasons, that FD's data were not excluded from analyses and it is considered unlikely that this has affected the overall findings.

Table 3 presents overall mean values and 95% confidence intervals for the first and second sets of data. Overall, the mean end of year score was 50.9, compared with a start of year score of 49.6, not a statistically significant difference, but a demonstration, nevertheless, of some improvement.

A total of 61 FDs completed both the exercises. Comments relating to the two FDs who achieved the lowest score included "no resistance to distal displacement", "possible exposure at the axial wall" "overcut cavity"(amalgam cavity), 'high marginal

ridge which could fracture under occlusal loading' (amalgam restoration), 'poor contour and no interproximal contact' (composite restoration), 'insufficient reduction and impossible withdrawal' PFM crown preparations).The mean score, overall, for the first exercise was 63.42, while the mean score for the second exercise was 65.24. Table 3 also presents the mean values of marks and related confidence intervals for start of year and end of year exercises. The cumulative scores from all groups increased slightly. However, the increase in total score was not statistically significant (P=0.31). A similar pattern was observed for all examined clinical domains with an exception of amalgam restoration for which the increase was found statistically significant (P=0.012). Regarding the amalgam cavities, there were few preparations which were under-prepared, with the most common failing being over-preparation in a pulpal direction, either at the pulpo-axial wall or at the floor of the occlusal lock, with the assessor considering that there was a likely pulpal exposure in at least three preparations, with Figure 2 presenting two examples. Regarding the resin composite class IV restorations, most common among the problems observed was the lack of a contact point or an incorrectly contoured mesial-incisal angle. While neither of these problems would result in damage to the tooth, it may be considered that either or both could be aesthetically unacceptable to a patient and would be likely to result in a patient re-attendance. The labial surface of some restorations was found to be concave in a number of cases. Figure 3 presents a composite restoration which achieved a score indicating major problems. Regarding the crown preparations, a particular failing observed in the previous audit was the lack of a chamfer in many preparations. This was again apparent, indicating a less than clear understanding of what a chamfer preparation looked like, nor why it was appropriate to the palatal aspect of the metal-ceramic crown preparation.

We also examined the differences according to the training site. Table 4 and figure 1 show that the total score was slightly increased in three training sites. However, the increase was statistically significant only for Training Site B (P=0.01). The mean values of scores for each examined clinical domain and associated P values are also presented for each training site. For example, while the scores for PFM Crown decreased significantly in Training Site C (P=0.03), the same score improved and was statistically significantly for those who underwent training in Training Site D (p=0.02).

Discussion

The present work has used a standardized assessment in order to objectively measure progress with operative skills during the FDs' training programme. In an ideal investigation, two or more examiners might have been used, but this was not possible in the present study. However, the reliability of the examiner in the present study had been demonstrated in the previous work[4].

The data for 62 dentists who completed their FD training in general dental practices across five schemes, based on geographical areas in England were analysed, evaluating the performance of trainees by comparing their scores at the beginning of their training in 2013 and their scores towards completion of training in 2014. Five clinical skills were evaluated (Porcelain fused to metal (PFM) crown preparation, PFM crown preparation using a putty index, composite class IV restoration, class II amalgam preparation, and class II amalgam restoration). In this regard, the relevance of the findings is reinforced by the results of work published a quarter of a century ago which indicated that the several features of cavity design were associated the survival time of the restoration or with the reason for replacement[7].

There have been few published previous attempts to measure the adequacy of dental cavity preparations, performed by dental students/graduates, with Charbenau's system of classification[8] being based upon four dimensions and a five-point scale. However, it has been considered that the use of terms such as "moderate" and "slight" in the classification were ambiguous and could lead to biased reporting[9]. As a result, Jokstad and Mjor, in 1987[10], defined criteria for external outline, external cavity definition, margin roughness and internal cavity definition, with five different scale points. It was considered that that system was too complex for the present study, hence the development of the present, simplified, scoring system, which has been considered to work satisfactorily in the present study and in previous work[4].

The results indicated a general overall improvement in performance over the FD year, but with the improvement being statistically significant only for the amalgam restoration. The reason for this may only be surmised, but could be related to the fact that this is one of the clinical treatments which the FDs performed most often for their patients. It may also be of interest to note that only one group, overall, demonstrated significantly improved scores over the evaluation period and it should be pointed out that the scheme whose results improved most was also the scheme which started with the lowest initial score in August 2013.

Other potential factors affecting variation in performance and improvement could be the teaching and/or counselling of the Course Tutor, or whether the group simply were more prepared to take the messages from the first audit on board. In addition, there is anecdotal evidence of the substantial role that the educational supervisor (trainer) in the training practice plays. In this regard, were the trainers and FDs in the scheme which improved its scores over the FD year more dedicated, better trained

or better motivated? The fact that group B was significantly worse than the others at the start may be relevant, because either they would have found it easier to demonstrate improvement from a lower base, or potentially could have been more motivated to demonstrate an improvement (Hawthorn effect or competition between schemes). Furthermore, there are 60 or so different trainers and many different lecturers and training programme directors involved in the training programme, together with a different patient base in individual training practices. On the other hand, the observed statistically significant improvement by just one scheme may just be a matter of chance.

Further analysis that might prove useful to determine whether any other factors may have contributed to the FDs' performance include school of graduation, gender, and/or performance in previous (undergraduate) assessments. However, these data were not available for analysis. However, in this regard, previous work has indicated that pre-admission students' scores in New Zealand did not predict performance in the undergraduate dental programme[11] and the relationship between academic record and clinical performance has been demonstrated to not be clearly defined [12,13]. Similar difficulties in predicting of the FDs' performance in a clinical exercise may therefore exist.

As in the previous study[4], there was wide variation in the operative performance of the dentists, something which has been identified in a number of previous studies[14-17]. There also were a number of commonly observed operative failings, principal among these being the palatal preparation for a shoulder in a crown preparation, when a chamfer preparation was suggested as appropriate. There were also a number of amalgam cavities which simply could not have retained a restoration for an extended period of time (Figure 4). While this might not directly result in pulp

death in the way that an over-prepared cavity might, it would be a potential source of discomfort and inconvenience to a patient whose restoration was prematurely lost.

The reasons for a lack of statistically significant improvement across the range of clinical activities may only be surmised. After nine months when the FDs were treating “live” patients with natural teeth, unfamiliarity with the equipment and surroundings on returning to a clinical skills simulation (phantom head) suite, and the use of plastic teeth, may have contributed to this: however, such difficulties did not prevent a third of the FDs carrying out satisfactory preparations and/or restorations, two examples of which are presented in Figure 5. Furthermore, while the FDs may have used the first session as a retraining exercise to re-acquaint themselves with clinical work after *circa* three months’ break from clinical activity, in the knowledge that they would be presented with the results and feedback from that first exercise, the FDs may have looked upon the second session as an administrative exercise in which there was little or no benefit to themselves, hence the failure to improve across the board. A question should therefore be asked – did all the trainees take the exercise seriously on both occasions? Perhaps there may have been little appetite to undertake the follow up exercise for reasons which require further investigation. Any lessons learned could be extended throughout the national FD scheme.

Another question which might be posed is – has the manual dexterity of the FDs improved over the nine month training period, and, a second question could be – how long does it take for a qualified dentist to reach the zenith of hand/eye co-ordination and skill?. The answer to these questions is not known, but, the results of the present study would appear to indicate that nine months’ clinical activity is not sufficient for all of these recently qualified dentists to have reached top performance.

However, while the present study has assessed only the FDs' restorative skills, results of a study of Foundation Trainers in England and N Ireland indicated that *circa* 40% of new graduates were unable to undertake a surgical extraction on their own[18]. Given that this may have been as a result of limited experience, it may be surmised that the FD year may enhance the participants' confidence in a variety of dental disciplines as a result of the volume of treatment that they carry out, with a helping hand close by for advice should problems arise. In this regard, Honey and colleagues, when studying confidence levels (as opposed to competence levels) of final year dental students, found that the highest confidence levels were reported for minimal-intervention treatments such as fissure sealants, scale and polish and oral hygiene instruction[19]. Lower levels of self-reported confidence were found for restorative treatments such as crown and bridge preparation, although confidence in amalgam restorations scored relatively highly[19]. With these data in mind, It may therefore be considered surprising that "amalgam restoration" was the one item which showed a significant improvement in the present study.

Finally, it may be gratifying for those in charge of the FD scheme to learn that their funding has resulted in an improved performance, albeit only being statistically significant with regard to amalgam restorations. The aims of the FD scheme include the following[1]:

- To enable the dental practitioner to practise and improve the dental practitioner's skills;
- To introduce the dental practitioner to all aspects of dental practice in primary care;

- To identify the dental practitioner's personal strengths and weaknesses and balance them through a planned programme of training;
- To promote oral health of, and quality dental care for, patients;
- To develop and implement peer and self-review, and
- promote awareness of the need for professional education, training and audit as a continuing process

The results of the present study deal only with the practitioner's clinical skills, and, perhaps, their ability to self-review, but the fact remains that results indicate that the FD training scheme afforded to newly graduated dentists is a pillar in their early professional development, potentially enhancing their clinical performance and confidence for a career stretching forty years into their future. While their clinical performance (as defined by the phantom head exercises utilised in the present study) may not have improved in a statistically significant way across the board, other skills, such as communication and patient management, should also be considered and these could also usefully be assessed. The likely introduction of assessed satisfactory completion of dental foundation training in England Wales and Northern Ireland from 2016 will address this very important area. In that regard, Scotland has been assessing satisfactory completion of Vocational Training for many years.

Conclusions

There was variability in the performance of the FDs. The audit of the clinical operative performance of FDs at the commencement and end of their FD year has

indicated an overall moderately improved performance over the year and a particular improvement in their performance with regard to amalgam restoration.

Acknowledgments

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Table 1: Original criteria for the assessment of the preparations/restorations carried out by the FDs[4]

KEY Indirect	**1 OPTIMAL**	**2 CLINICALLY ACCEPTABLE**	**3 UNSATISFA**
Occlusal surface			
Reduction	Ideal space for chosen materials (1.5 & 1mm)	Errors (but restoration could be made)	Over/under -p
Contour	Pre-operative contour obvious	General features present	Loss of co
Margins			
Shoulder	Uniform 1mm depth, follows gingival contour	Areas of under/over preparation	Insufficient room for /Unnecessary toot
Chamfer	Uniform 0.5 mm depth, follows gingival contour	Some sub-optimal areas	Margins unacceptab
Axial surfaces			
Reduction	1.5mm Alloy + Porcelain	Restoration could be made	Insufficient room /Over-prep

Axial length	Optimum	Adequate retention form	Insufficient r
Convergence angles	Optimum 5-10°	Adequate 10-20°	>20° / Un
Outline form	Optimal Resistance form (conforms to premolar outline)	Adequate resistance form	Loss of shape/poor
Surface finish	All surfaces smooth/ rounded line angles	Clinically acceptable	Poor finish/shar
Iatrogenesis	Zero	Minor damage (consistent with hand instrument)	Bur dam

COMPOSITE RESTORATION	**OPTIMAL** **1**	**CLINICALLY ACCEPTABLE** **2**	**UNSATISFACTORY** **3**
Labial contour	Optimal	Over or under contoured	Grossly over or under contoured
Incisal edge form	Parallel to interpupillary line Optimal thickness/position	Some errors	Unsatisfactory
Proximal contour	Optimal	Sub-optimal	Concave or otherwise unsatisfactory
Palatal contour	Optimal	Over or under contoured	Grossly over or under contoured
Contact	Optimal tightness + contour	Tight but contour defects	Open contact
Margins	Optimal	Minor excess	+ve/-ve ledge Rough or stained
Voids/layers	None	Minor (will not affect longevity/aesthetics)	Major defects
Surface finish	Optimal	Some rough areas	Rough generally subject to stain
Iatrogenesis	None	Minor (consistent with hand instrument/disc/finishing	Bur damage

		strip)	

Amalgam Preparation	**1**	**2**	**3**
Proximal box			
Design	Optimal	Clinically acceptable	Unsatisfactory
Depth	Sufficient to remove caries/cervical contact clear/~3mm	Clinically acceptable	Insufficient for lesion Cervical contact remains
Margins	Optimal	Sub-optimal	Fragile enamel/rough
Iatrogenesis	None	Minor (hand instrument)	Bur damage
Occlusal lock			
Design	Optimal	Clinically acceptable	Unsatisfactory
Depth	1.5-2.0 mm	Clinically acceptable	Over-preparation Pulpal exposure insufficient space for amalgam

Amalgam Restoration	**1**	**2**	**3**
Anatomical form	Optimal	Some errors	Unsatisfactory
Contact point	Optimal Tight / natural contour	Sub-optimal	Open Food trap
Marginal ridge height	Optimal Same as adjacent teeth	Clinically acceptable	**Too high** Fracture risk **Too low** Food trap Weak

Surface finish	Smooth contour throughout	Clinically acceptable	+ve/-ve marginal ledges Voids Rough / pitted

Table 2. Allocation of recoded scores to each examined clinical skill

	Number of assessment criteria	**Range**
PFM1	10	0-20
PFM & Index	10	0-20
Composite Restoration	9	0-18
Amalgam Preparation	6	0-12
Amalgam Restoration	4	0-8
Total Mark	39	0-78

Table 3. Mean values of scores and their 95% confidence Interval for start and end of year exercises

	Start of year		**End of year**	
	Mean	**Confidence Intervals**	**Mean**	**Confidence Intervals**
PFM1	17.46	(16.71- 18.21)	17.55	(16.9,-18.2)
PFM + Index	16.78	(15.87- 17.7)	16.83	(15.67- 18)
Composite Restoration	15.05	(14.49- 15.61)	15.11	(14.51- 15.7)
Amalgam Preparation	8.43	(7.69- 9.17)	9.36	(8.75,-9.97)
Amalgam Restoration	5.98	(5.58- 6.38)	6.55	(6.12,-6.98)
Total Scores	63.42	(60.92- 65.93)	65.24	(62.68- 67.81)

Scheme	PMF			PMF+Index			Composite Restoration			Amalgam Preparation			Amalgam Restoration			Total score		
	start	**end**	**P Values**	**start**	**end**	**P Values**	**start**	**end**	**P Values**	**start**	**end**	**P Values**	**start**	**end**	**P Values**	**start**	**end**	**P Values**
A	18.1	17.8	0.11	17.9	16.3	0.90	15.2	15.5	0.44	10.1	10.1	0.69	6.6	6.9	0.58	67.8	68.0	0.84
B	15.8	17.4	0.20	14.9	18.7	**0.04**	14.9	15.4	0.72	7.9	9.9	**0.05**	5.3	7.0	**0.01**	58.8	71.3	**0.01**
C	18.8	16.0	**0.03**	18.7	16.4	**0.04**	15.2	13.9	0.21	6.8	7.5	0.41	5.8	5.9	0.64	65.3	58.3	0.11
D	17.3	19.4	**0.02**	16.3	17.4	0.17	13.9	15.5	0.24	7.9	10.3	**0.02**	5.7	7.0	0.02	61.2	69.5	0.08
E	17.1	17.3	0.72	15.6	14.9	0.70	16.2	15.5	0.46	9.7	9.7	0.58	6.5	6.5	0.71	63.8	63.5	0.30

Table 4. Start and end of FD year scores per exercise according to Training Site, with p values

Figure 1. Mean values of total scores in each training site at the start and end of the programme

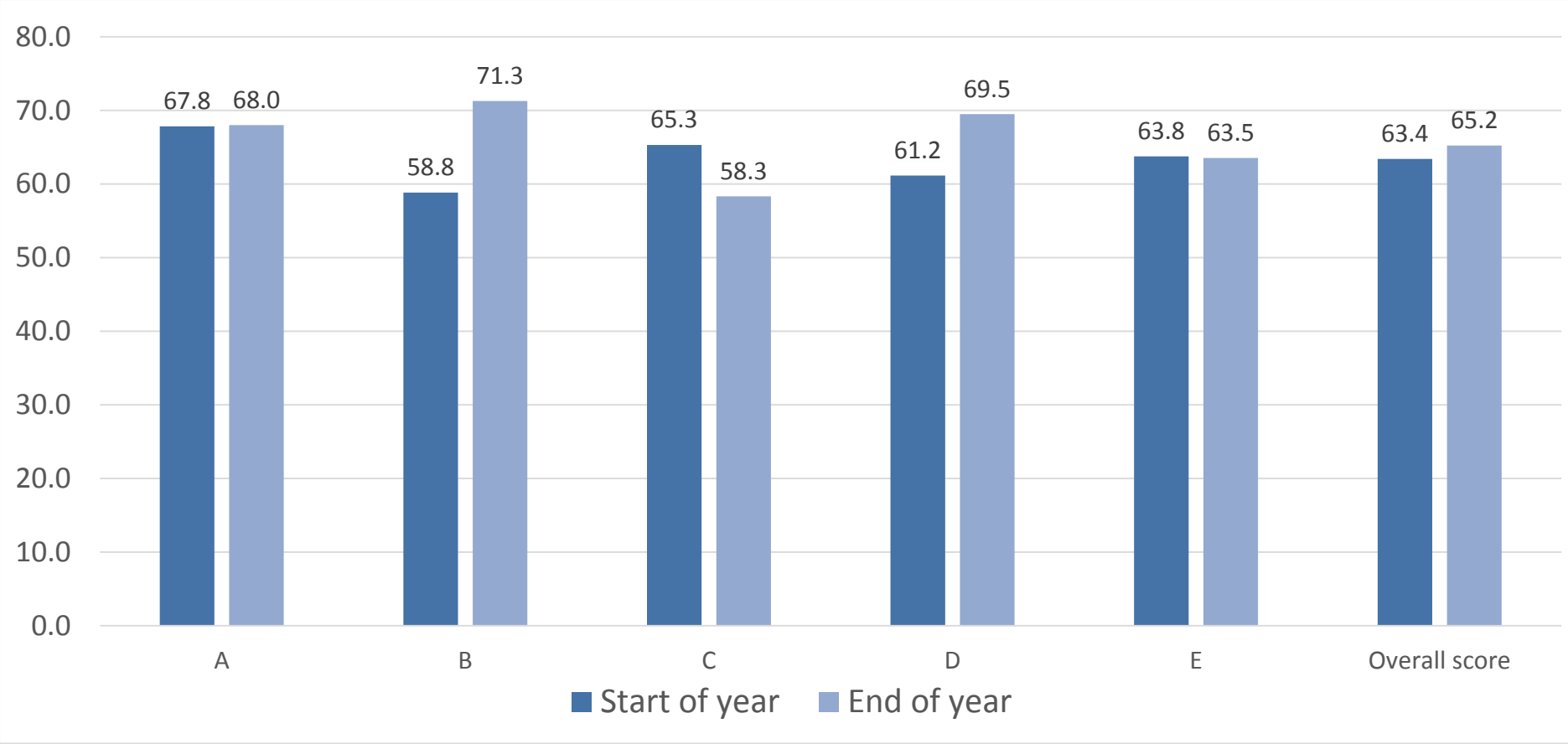

Figure 2a: Amalgam cavity preparation in which a pulpal exposure was considered likely: heavy pressure on the bur (possibly with lack of coolant) has caused burning of the plastic tooth

Figure 2b: Non-retentive amalgam cavity preparation with several possible exposure sites and iatrogenic damage to the adjacent tooth.

Figure 3 Defective class IV resin composite restoration

Figure 4. Non–retentive amalgam cavity preparation: no resistance to distal displacement of the restoration

Figure 5a: An example of a restored class IV restoration which was considered reasonable, albeit with a couple of surface imperfections

Figure 5b: An example of a restored class II amalgam restoration which was considered satisfactory