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Journal of Dental Problems and Solutions

CLINICAL GROUP

ISSN: 2394-8418 DOI: https://doi.org/10.17352/jdps

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Received: 02 March, 2019
Accepted: 11 March, 2019
Published: 12 March, 2019

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Research Article

Influence of structured reporting of tooth-colored indirect restorations on clinical decision-making

Abstract

The aim of the present study was to discover what influence structured reporting (study group = A) of toothcoloured lab-fabricated restorations has on clinical decision-making following international guidelines. By way of comparison, the conventional approach in the form of short reporting with 5 items (control group = B) was used as gold standard. The study was carried out in the first clinical semester of dentistry (n = 68) at the Goethe University in Frankfurt am Main. In the study group, indirect ceramic restorations were assessed on a scale of 1 (very good) to 5 (insufficient) using structured reporting (7 items, each with 5 subgroups) in accordance to World Dental Federation (FDI) - standards. Following this, the clinical decision on the insertion of the restoration was made. To evaluate the quality of the structured reporting, sensitivity, specificity, confidence intervals (CI) and the respective predictive values (positive = PPV, negative= NPV) were determined. Based on FDI reporting, a ceramic inlay is also favored with a great degree of certainty in clinical decisions: this was the true in 34 procedures out of a total of 38 clinically incorporated ceramic inlays [sensitivity 67% (95% CI: 46%83%); specificity 89% (95% CI: 75%-97%); PPV 82%, NPV 79%]. In the control group, sensitivity was 56% (95% CI: 35%-75%); specificity 92% (95% CI: 79%-98%); PPV 83%, NPV 74%. No significant differences could be determined between A and B (p = 0.813).

Due to the higher sensitivity and efficiency given comparable specificity, structured reporting of tooth-coloured lab-fabricated restorations based on FDI criteria, appears more recommendable than short reporting. It is also suitable for promoting decision-making in quality assessment, thus improving the durability of dental restorations.

Introduction

More than 40% of the world's population suffer from untreated tooth decay that requires therapy [1]. In cases of caries, patients receive suitable treatment, for example direct fillings or indirect restorations such as inlays or crowns. Today, treatment with ceramic or composite tooth-coloured inlays is regarded as a routine procedure. Failures in ceramic restorations were related to fractures/chipping (4%), followed by endodontic complications (3%), secondary caries (1%), debonding (1%), and severe marginal staining (0%). Odds ratios (95% confidence intervals) were 0.19 (0.04 to 0.96) and 0.54 (0.17 to 1.69) for pulp vitality and type of tooth involved (premolars vs. molars), respectively [2]. However, almost a third of these require further treatment within four years ("reentry") for example a partial repair or a new restoration. Adverse events (AEs) such as diverse technical problems, pain or even the failure or loss (SAE serious adverse event) of a restoration may occur [3]. It is therefore no surprise that dentists and patients spend the majority of their time (more than 60%) with the application, restoration and replacement of restorations [4]. The literature makes clear that as early as the diagnostic process occures, a structured approach can allow a more complete technical and clinical assessment, and thus be a solution to the problems described [5-10]. In the conventional approach (gold standard), parameters such as border seal, proximal contact strength, shape, surface smoothness and accuracy of fit (by means of an inside impression) are assessed [11]. Structured guidelines for assessment are seldom found [12]. If it is already possible during reporting to identify the above weaknesses, then the incidence of a re-entry, and with it of AEs and SAEs, could be lowered. Within structured reporting guidelines it is significantly easier to provide relevant contents and indications as effectively as possible. In addition, structured reporting with its clear sequence facilitates the clinical findings themselves. A number of concepts are subsumed under the term structured reporting, including the implementation of checklists and criteria [5,6]. In 2010, the World Dental Federation (FDI) revised the clinical criteria for the assessment of direct (fillings) and indirect (inlays, crowns) dental restorations and provided, amongst other things, the

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possibility of training in the area of clinical decisionmaking [13]. In this way, the achievement of those learning objectives explicitly referred to in both National Competency-based Learning Objectives Catalogues in Medicine (NKLM) and in Dentistry (NKLZ) can be taken into account – that students should learn patient consultation from the viewpoint of (dental) medical concerns and have to implement decision making appropriate to dentistry [14,15].

Several areas of medical training are devoted to the problem described above, however, terms such as clinical decision-making or structured reporting have seldom made the move into the teaching of dentistry [16-18]. In a recent short Pubmed investigation, the keywords "clinical reasoning AND dental AND structured reporting" revealed no hits (state of search: 26.02.2019). In the light of this, the aim of the present study was to discover what influence structured reporting in accordance to FDI-standards (study group = A) of tooth-colored labfabricated restorations has on clinical decision-making. By way of comparison, the conventional approach in the form of short reporting (control group = B) was used as a gold standard.

Materials and Methods

Investigation period and setting

The experimental setting includes the data from a total of two clinical cohorts from each respective sixth semester of Dentistry. The period of investigation ran from the beginning of the winter semester 2014/2015 to the end of the summer semester 2015.

Study participants

Study participants were students of dentistry at the Dental University Institute of the Carolinum Foundation in Frankfurt on Main; they were enrolled in the first clinical course of conservative dentistry. The overall population consisted of 80 students, of which 31 were from the winter semester 2014/15 and 49 from the summer semester 2015.

Implementation

The course of the study is shown in figure 1. During the first clinical semester (6th semester) preparations for performing an indirect restoration (inlay) are carried out on extracted human teeth, after the theoretical principles for this have first been taught (duration of instruction 4 x 60 minutes). In the study population, 65 preparations on human teeth occurred in a simulation model. The preparation and the following restorations (65 composite inlays and 65 ceramic inlays) were produced based upon a prescribed SOP (standard operating procedure) protocol (Figure 2). For the treatment of each tooth, both a composite and a ceramic inlay were available. Each student then assessed both inlays on the human simulation model using two different assessment sheets with (study group) and without (control group) modified specifications of the FDI (Figure 3). Prior to the assessments, in a one-hour session students received both theoretical and practical instruction in proper use.

In the study group, two scales (aesthetic and functional parameters) were used to assess structured findings, consisting of a total of 7 items each with 5 subgroups. In the control group, a shortened valuation variant was used, also consisting of 2 scales (aesthetic and functional characteristics) and 5 items that corresponded to conventional procedure (gold standard). In both reporting sheets, assessment was conducted on a scale from 1 (very good) to 5 (insufficient). Following the evaluation using the respective reporting sheets, the clinical decision was made for one of the two restorations. Here, students were offered the possibility of explaining in free text commentary how they had come to their respective clinical decision. For the assessment of the quality of the two methods of structured reporting, the sensitivity and the specificity confidence intervals (CI) and the respective predictive values (positive: PPV, negative NPV) were determined.

Statistics

Statistical analysis was carried out in cooperation with the Competence Centre for Exams in Medicine in Baden Württemberg, Medical Faculty, Heidelberg, Germany. All evaluations were carried out using the program R version 3.4.4, packet epiR version 0.9-93. Determination of sensitivity and specificity, as well as positive and negative predictive values was conducted using the asymptomatic chi^2 test. Significance was tested using the exact Fisher test.

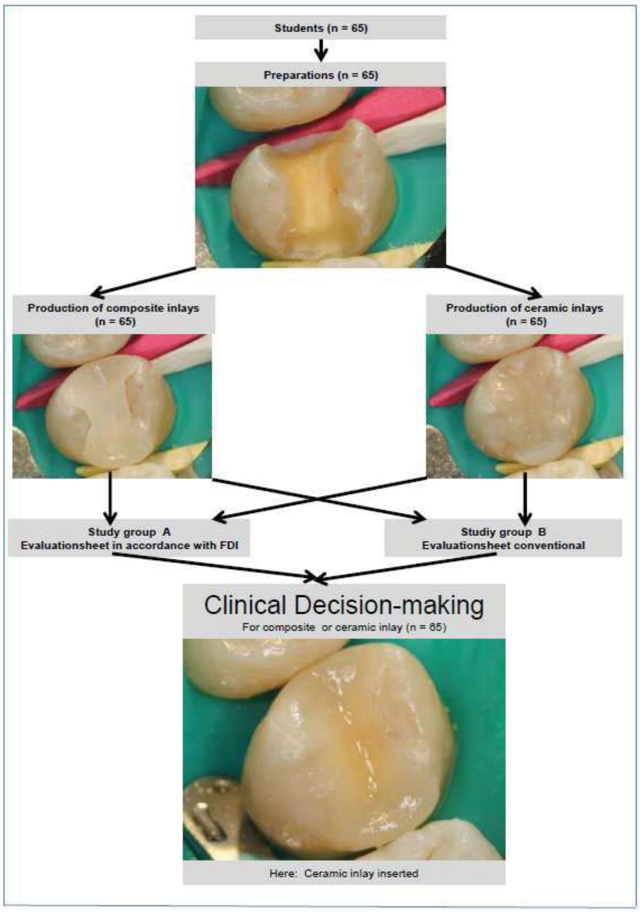

Figure 1: Flow chart of the Study.

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	Standard Operating Procedure (SOP for indirect Restorations (inlays) *ceramic / composite; Steps 1 to 31*		
	What?	How?	With what?
1	Preparation	Partial dental impression, Contour form/caries removal, Build-up filling (crown preparation)	Plastic spoon (aluminum spoon) SilaPlast/Soft, diamond, round bur, SuperCure contrast/natural
2	Planning	Note spread of caries, Note proximal situation, Note crown axis	Defective impression (mold 3 times!), X-ray Preoperative models (articulators if necessary)
3	Sample preparation	Complete filling of the defect, Test preparation (breadth, depth, crown axis)	Plaster (plastic), Diamonds, manual instruments
4	Primary preparation	Simple, defect-oriented box-shaped basic geometry, Sufficient thickness / minimum thickness: 1.5 mm (intra coronal), Blocking out of undercuts before preparation (with suitable under filling), Occlusal divergence of cavity walls (approx. 10-12° convergence angle), Smooth spherical cavity floor, smooth inner surfaces, Soft inner contour transitions, rounding off of sharp inner edges, No tapering of the cavity edges	Conical, rounded diamonds, manual instruments, Check using Futar bite, Using build-up filling, Conical form Rotating or oscillating grinding tools Rotating or oscillating grinding tools Rotating or oscillating grinding tools
5	Secondary preparation	Sharp preparation border (no tapering), refinishing of the cavity	Ultrasound/ -sonic approaches
6	Final check	Post-occlusal diverging walls (10-12°), Undercut areas and bevel or segment impression	Probe, mirror, dry field, Probe, mirror dry field; SilaSoft,
7	Provisional production	Partial impression and provisional plastic (processing time, setting test), Securing of vertical and horizontal dimensions (contact points), Preparation outside the oral cavity	Pro-Temp (BisGMA), Occlusal paper, dental floss Hand or angle piece, milling, diamonds, polisher
8	Impression	Conventional or digital impression	Impregnum or CAD/CAM
9	Inlay production	Laboratory fabricated	Individual character
10	Check prior to seating	Visual marginal check, Screening for the detection of material defects (fissures)	Dental loupe, Polymerization light
11	Removal of temporary restoration	Without damaging the preparation	Scaler, Heidemann spatula, Hollenback, ultrasound
12	Cavity cleaning	Remove the remains of the cement without damaging the preparation	Scaler, probe, brushes
13	Protection against aspiration and choking	Cover throat	Gauze
14	Proximal adjustment of restoration	Gradual adjustment, Check	Occlusal paper, hsite, lipstick, no occlusal spray, fine grit diamond, silicone polisher, matrix tape (dental floss)
15	Removal of temporary restoration	Inner impression, disruptive areas push through	SilaSoft
16	Marginal check of restorations	Positive, negative levels (adhesive lines)	Probe, dental floss, fine grit diamond, silicone polisher
17	Documentation of structured reporting	Written	FDI findings sheet / summary report
18	Clinical decision making	Evaluation of results and individual parameters, Decision for ceramic OR composite inlay	FDI findings sheet / summary report
19	Complete dry field	With multisided restorations including adjacent teeth Pre-wedging, preparation border accessible	Dental dam instruments Wedges
20	Conditioning of restoration	Grip with forceps. 1a. Etch ceramic inner surface of inlay 20-60 secs (depending upon material), b. Rinse in kidney dish, dry, wet with silane (exposure time 60 secs), evaporate, 2a. Roughen composite surface, etch for 20-30 secs, rinse and dry	Diamond forceps, Hydrofluoric acid (yellow) Water, neutralizing powder, silane Round bur, phosphorus acid
21	Conditioning of cavity	Analogous to composite filling: carefully disperse bonding, Cave: Pooling	Optibond FL
22	Mix luting composite	Automix (observe line length)	Plastic spreader, application needle, Variolink esthetic
23	Apply luting composite	Only in the cavity, fill approx. 1/3, spread	Plastic spreader, brush
24	Remove excess	Hold occlusal restoration, remove carefully	Foam pellet, probe, Wiland, dental floss
25	Apply airblock	To the complete adhesive line	Application needle
26	Polymerization	From each side, proximal both sides, occlusal	Polymerization light
27	Removal of excess	Carefully, little contact with dental enamel	Diamond finishing instrument
28	Remove completely dry field	Carefully	Dental dam instruments
29	Polish	Analogous to composite filling	Analogous instruments, possibly diamond silicon polisher
30	Final check	Assessment of results and individual parameters	FDI findings sheet, summary of findings (probe, dental floss
31	Flouridation	Touch	Elmex jelly

Figure 2: SOP for indirect restorations.

Assessment Sheet for Indirect Restorations

Your course number: ______________________

1. Please assess both inlays based on A. FDI criteria (seven parameters, see below) and B. Conventional criteria with five parameters (each in school grades 1-5)

	Ceramic Inlay (grades 1-5)	Composite Inlay (grades 1-5)
A. FDI Criteria		
Aesthetic properties		
1. surface		
2. shading		
3. anatomical form		
Functional properties		
4. fracture		
5. marginal adaptation		
6. proximal contact		
7. form of proximal contact		
B. Conventional Criteria		
Aesthetic properties		
1. smoothness		
2. occlusal configuration		
Functional properties		
3. border seal		
4. contact point		
5. internal impression		

2. Which inlay (ceramic versus composite) would you choose clinically and why?
Free text:

A. Aesthetic characteristics			
	1	2	3
A	Surface	Shading, translucency	Anatomical form
1	Comparable with enamel	Good color result	(almost) ideal
2	Somewhat dull, few isolated pores	Minimal difference	Slightly different
3	Dull, acceptable many pores	Clear difference	Different, but aesthetically still acceptable
4	Rough, polishing alone will not suffice	Clinically insufficient	Unacceptable, correction required
5	Very rough, unacceptable, replacement	Replacement required	Replacement of filling required

B. Functional Characteristics			
4.	5	6	7
Fracture	Marginal adaptation	Proximal contact	Form of proximal contact
No fracture, no fissure	Harmonious Ø gaps	Physiological	Physiological
No hairline fissure	Marginal gap < 150mµ, small level	Somewhat too firm, but acceptable	Somewhat inaccessible
Several hairline fissures	Gap > 250mµ large level	Too weak, repair required	Inaccessible
Partial fracture	Gap > 250mµ Small fractures Repair required	Too weak, repairs required	Inadequate contour
Fracture, loss of filling	Filling loose but still in situ	Too weak, filling replacement required	Insufficient tooth contour

Figure 3: Evaluation formsed.

Results

The study finally included n = 65 of 80 students. The initial drop-out rate of 15% (68 students) could be explained by the number of evaluation sheets not submitted. The second drop-out rate of 4.41% (65 students) resulted from the fact that the comments section on the evaluation sheets was not filled out, and thus those evaluations were not possible. The data were evaluated per protocol.

FDI-Reporting (study group)

By means of FDI reporting, a ceramic inlay is favored with a great degree of consistency in a clinical decision that is in 34 of 43 cases. In addition, FDI reporting is also well suited to the clinical preference (in 18 out of 22 cases) for non-ceramic alternative care (composite inlays). For the FDI reporting, a sensitivity of 67% (95% CI: 46%-83%) and a specificity of 89% (95% CI: 75%-97%) emerged. This resulted in a positive predictive value of 82% (95% CI: 60%- 5%) and a negative predictive value of 79% (95% CI: 63%-90%).

Conventional short reporting (control group)

In conventional short reporting, a ceramic inlay is favored with a great degree of consistency in clinical judgement, namely in 35 out of 40 cases. In addition, this type of reporting is also well suited for the clinical preference (in 15 out of 18 cases) for a non-ceramic alternative solution (composite inlay). For short reporting this results in a sensitivity of 56% (95% Cl: 35%-75%) and a specificity of 92% (95% Cl: 79%-98%. The positive predictive value was 83% (95% Cl: 59%-96%) and the negative predictive value was slightly below at 74% (95% Cl: 60%-86%).

Comparison of both groups

When comparing the study group FDI reporting and the gold standards of the conventional short reporting, a ceramic inlay is frequently evaluated equally (42 out of 46 cases). In the case of non-ceramic restorations, the assessment of the reporting sheets also largely coincides, specifically in 14 out of 22 cases. This results in a sensitivity of 78% (95% Cl: 52%-94%) with a specificity of 84% (95% Cl: 71%-93%). A PPV of 64% (95% Cl: 41%-83%) was calculated, and a NPV of 91% (95% Cl: 79%-98%). In the statistical evaluation, no statistically significant difference could be seen between the two evaluation sheets (p = 0.813).

Ultimately a total of 65 inlays were seated in the human simulation models; in the case of 23 of these, a clinical decision disregarding the criteria catalogue was made (35%). If the clinical decision was different to the results of the evaluation sheets, this was explained in a number of ways: 12 times due to the margin fitting, 6 times due to the proximal contact and twice regarding surface texture. Other less common reasons (one mention each) were: the adhesive bond, contouring, anatomical form and the color. In these cases, the above points were assessed as being clinically so serious that a decision based purely on the metrical data was regarded as inadequate.

Discussion

The literature shows that structured findings often reveal fewer linguistic ambiguities than free text findings [7]. This is especially the case when predefined structured elements tested by experts are used. Such structured elements were also employed in the present study. In addition, structured reporting presentations encourage the reporting physician to arrange the relevant information in a logical, ordered sequence. In conclusion, structured reporting contains more

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relevant information for the subject involved and is thus more complete [8]. These efforts at increasing the completeness of the findings lead to more reliability in clinical decision-making [9]. On the basis of this knowledge, reporting systems are increasingly used that are adapted to the clinical situation. Structured reporting would thus in principal allow for the parameters in question to be completely recorded, and in so doing allow more efficient reporting.

In 2015, Dobranowski presented varying levels of structured reporting [10]. Based on this, control group B (conventional criteria) of the present study can be positioned on level 4 and study group A, according to the FDI, on level 6. Thus the FDI reporting criteria (specified by the World Dental Federation) are subject to an internationally recognized system of evaluation that was created for use in studies as well as in the instruction of students [13]. A modification of the evaluation sheet used was that not all the criteria recommended by the FDI were integrated. The biological parameters were excluded, as the evaluation took place in a simulation situation on extracted teeth [13].

Comparable studies were able to establish similar sensitivities (78.6%) and specificities (85.9%) with the use of FDI criteria for the evaluation of restorations, as in the present study [19]. To qualify this, however, it has to be mentioned that the author group of Signori et al. evaluated photographs and not actual available restorations. Furthermore, the present findings can be used to determine the efficiency of a test method based on sensitivity and specificity. Guide values of around 160% for the sum of sensitivity and specificity were interpreted with an acceptable degree of efficiency in the literature [20]. In the present study, the sum for the study group is 156%, in the control group it is 148%, only slightly below the limit.

Through consideration of the assessed restorations, critical thinking and evaluation skills are encouraged. This is a considerable part of clinical decision making in everyday practice [16,17]. In addition, the clear guidelines for structured reporting enable students to recognize recurring patterns; this promotes the acquisition of professional experience and precise diagnosis [18]. In this way, it is possible to already identify weaknesses in the context of the reporting of indirect restorations in everyday situations, and the frequency of a re-entry can be lowered. The medium-term durability of restorations can thus be raised.

The present study should be looked at critically, as there are significant limitations. The size of the population is limited, attributable to the low number of dentistry students and the range of data. Students each assessed individual restorations by analogy with the treatment situation, so that no inter-rater reliability could be recorded. However, it was not the aim of this study to verify this, but rather to examine the applicability of the evaluation sheets and the resulting clinical decision-making.

The principle of the study can easily be applied to other situations. Not only indirect restorations can be assessed using the reporting forms, but direct care can also be evaluated. The FDI criteria are also designed for such purposes. In addition, they could be applied to clinical situations directly on patients, taking further parameters such as biological criteria into account (postoperative sensitivity and tooth vitality; recurrence of caries, erosion, abfraction; tooth integrity like enamel cracks, tooth fractures; periodontal response compared to a reference tooth; adjacent mucosa; oral and general health) [13]. There are other areas of medicine and dentistry conceivable, however, where structured reporting might be applied in order to improve judgement, for example when recording findings or assessing prosthetic dentures. The criteria used should in each case be adjusted accordingly.

Conclusion

Due to the higher efficiency and sensitivity at comparable specificity, structured reporting on level 6, according to FDI criteria for tooth-coloured, lab-fabricated restorations, appears recommendable in the context of clinical decision making. Consequently, it is a good resource for users in order to promote decision-making in quality assessment and thus improve the durability of restorations

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