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# Correlations Between Final-Year Dental Students' Performance on Knowledge-Based and Clinical Examinations

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**Title:**

**CORRELATIONS BETWEEN ACADEMIC AND CLINICAL PERFORMANCE  
EXAMINATIONS OF DENTAL STUDENTS**

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## **ABSTRACT**

**Purpose:** Undergraduate dental students are assessed using a range of methods in their final year examinations. The purpose of this study was to explore the correlations and predictive value of final year dental undergraduate students' performance on different types of academic and clinical assessments.

**Methods:** Examination data related to applied dental knowledge (ADK), exit case presentation (CP), and integrated structured clinical examination (ISCE) assessments for five consecutive cohorts of final year students from 2011-2015 was collated. The relationships between the scores produced by each assessment were investigated to explore the relative contributions of each to our understanding of students' abilities across the differing domains.

**Results:** The sample consisted of 304 individual students, comprising 147 (48.36%) females, 157 (51.64%) males. Significant positive correlations were observed between ISCE and ADK performance [ $r(391)=0.42, p<0.001$ ] as well as between ISCE and CP [ $r(391)=0.44, p<0.001$ ]. In addition, both ADK and CP performance were significant predictors (at  $p<0.001$ ) of ISCE performance.

**Conclusions:** This study provides important information about the relationship between students' performance across applied dental knowledge (ADK) and clinical (ISCE and CP) domains and highlights their predictive value. Further research is required to establish if these findings can be generalized and to explore the correlations between performance of dental students before and after graduation.

**Key Words:** Academic, Assessment, Clinical, Dental, Examinations, Performance.

## INTRODUCTION

Undergraduate dental students are assessed using a range of methods in their final year examinations. Knowledge is typically assessed using multiple choice and short essay questions (MCQs and SEQs). Assessment of clinical skills is usually carried out using objective structured clinical examinations (OSCE) and case presentation (CP).<sup>1,2</sup> Although knowledge and clinical skills are often regarded as distinct domains, evidence from medical students shows that the development and consolidation of clinical problem solving and diagnostic skills in their future professional careers is influenced by the knowledge domain.<sup>3</sup> Therefore, different types of assessments should not be treated in isolation as all domains contribute to the students' preparedness for practice. The learning activities and assessments need to be mapped against the core learning outcomes of a graduating dentist to facilitate their preparedness for practice after graduation.<sup>4</sup> Data from medical students has also shown that the relationship between didactic achievement and clinical performance examinations may be used to predict performance after graduation.<sup>5,6</sup> Moreover, identification of relationships amongst different types of assessments may help inform curricula and assessment development in undergraduate programs.

Final year dental students at our school are examined using three different summative assessments, namely, progress tests, case presentations and integrated structured clinical examinations which are briefly described below.

## **Progress Tests**

Progress testing is a form of longitudinal assessment of cognitive knowledge at regular intervals over the course of an educational program and its use is now firmly established in undergraduate programs in medicine.<sup>7-11</sup> Our school was the first dental school to use progress testing as a major summative academic assessment in dentistry and we have previously published our experience in the use of progress testing.<sup>12, 13</sup> The standard of each progress test, referred to as Applied Dental Knowledge (ADK) test, is set at the level of knowledge expected from a newly qualified dentist as outlined in the learning outcomes for dentists by the General Dental Council (GDC).<sup>14</sup> Tests are repeated twice a year (month 3 and month 9 in each academic year) for the duration of the course. Growth in applied dental knowledge is indexed by a steady increase in scores achieved.

The ADK tests are formative in years 1 and 2 and summative in subsequent years, including the final year. Each test is based on 100 single best answer multiple choice items. Questions are written around an appropriate clinical vignette and are aimed at testing the analysis, synthesis and application of knowledge as opposed to mere factual recall. The students choose their answer from 5 options or can choose a 'Don't Know' (DK) option. A score of 1 mark is awarded for each correct answer; minus 0.25 for an incorrect answer and 0 for 'Don't Know'. The results of the two ADK tests in the final year are combined to calculate the end-of-the-year grade (pass /fail) for the academic module.

## **Case Presentation**

Dental students in the final year are required to prepare an exit case presentation (CP) to demonstrate competency in clinical treatments on patients provided by the students under supervision during their placements on clinics. The students are required to prepare their exit cases on patients who need treatments encompassing at least three distinct disciplines of clinical dentistry. Every aspect of assessment, treatment planning and treatment delivery is carried out by the student under supervision and recorded on the clinical data base. The students then present and reflect on the clinical management of their patients in a summative examination which is assessed by a pair of examiners at the end of the final year. Assessment forms for CP are included in Appendix 1.

## **Integrated Structured Clinical Examination**

**In addition to assessment of competency in clinical skills on patient-clinics throughout the program, final year dental students have additional assessments referred to as integrated structured clinical examinations (ISCEs) at the end of the final year. The ISCE examination is generally similar to traditional OSCE.<sup>15</sup> However, in contrast to an OSCE which often tests individual skills on separate stations (e.g. history taking, examination), the ISCE aims to represent the real clinical situation more authentically by having longer stations at which students must demonstrate complex combinations of skills.<sup>16</sup> The students rotate through stations related to four clinical disciplines: restorative dentistry; pediatric dentistry /orthodontics; oral surgery; and oral medicine. Each typically lasts 30 minutes and usually involves multiple**

**aspects of management of a single patient such as assessment, diagnosis, operative skills, follow-up and referral.**

The aim of this study was to explore the relationship between, and predictive value of students' performance on academic (ADK) and clinical (CP, and ISCE) assessments.

## **METHODS**

Ethical approval for this study was obtained from the Institutional Review Board (Reference Number 16/17)-695). Examination data from ADK, ISCE and CP assessments for five consecutive cohorts (2011-2012 to 2015-2016 academic years) of final year dental students was collated. The sample consisted of 304 individual students, comprising 147 females, 157 males. Repeat assessments and resit years result in some students having multiple data-points when longitudinal historical data is combined; this has been factored in to the models where necessary. Summary statistics for each cohort are presented in Appendix A.

### **Data Analysis**

ADK percentage scores for the two tests sat by each student each year have been standardized (Z-Scores) for each assessment, and averaged to give each student a single numeric ADK score for the year.

Case presentations are graded Unsatisfactory, Borderline, Satisfactory, and Excellent across six criteria. These have been scored 1/2/3/4 respectively, summed, and standardized (Z-Scores) within year to give a numeric score for each student.

The ISCE assessment comprises several different stations, each comprised of a number of elements. Each element is given a categorical score with an associated numerical score which reflects the relative importance of each element. These scores are summed to provide a percentage score for the assessment, and these have been standardized within each cohort to provide Z-Scores for each student.



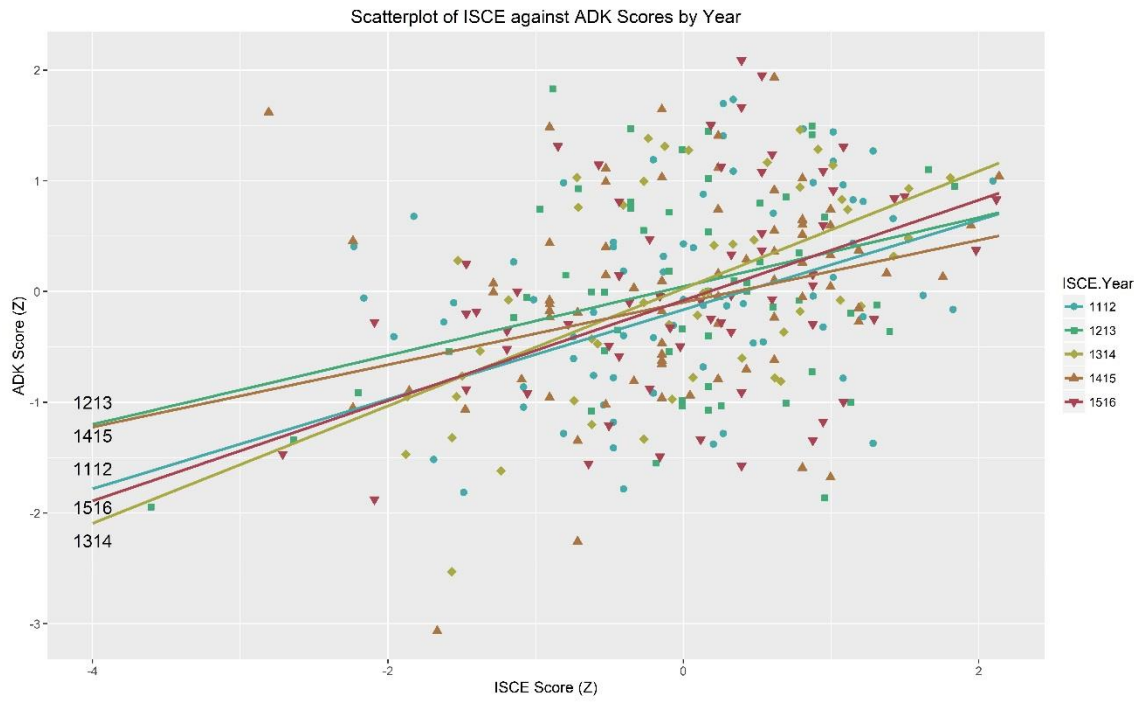
To study the relationship between the scores produced by the ADK, ISCE and CP, correlation coefficients were calculated for each pair of assessments, and the relationships depicted graphically in scatter plots. After establishing relationships between the various assessment scores, linear regression models were constructed to further evaluate the extent to which ADK and CP scores predict ISCE performance individually and in combination after controlling for demographic variables. Analyses were conducted using R for Windows (v3.1.3, R Foundation).<sup>17</sup>

## RESULTS

The sample consisted of 304 individual students, comprising 147 (48.36%) females, 157 (51.64%) males. All students who were eligible, signed up for the final year examinations. Repeat assessments and resit years resulted in some students having multiple data-points when longitudinal historical data is combined; this has been factored in to the models where necessary.

### **Correlation between ISCE and ADK performance**

ISCE (Z-Score within Year) and ADK (Averaged Z-Score within Year) performance are significantly correlated [ $r_{\text{partial}}(388)=0.41, p<0.001$ ]. The relationships between ISCE and ADK scores for each student (point) in each year (color), along with lines of best fit (colored by year) are depicted in Figure 1. Correlations between the two performance measures are also statistically significant for each year individually (Table 1).



**Figure 1 Scatterplot of ISCE Z-Score against ADK Z-Scores by Year**

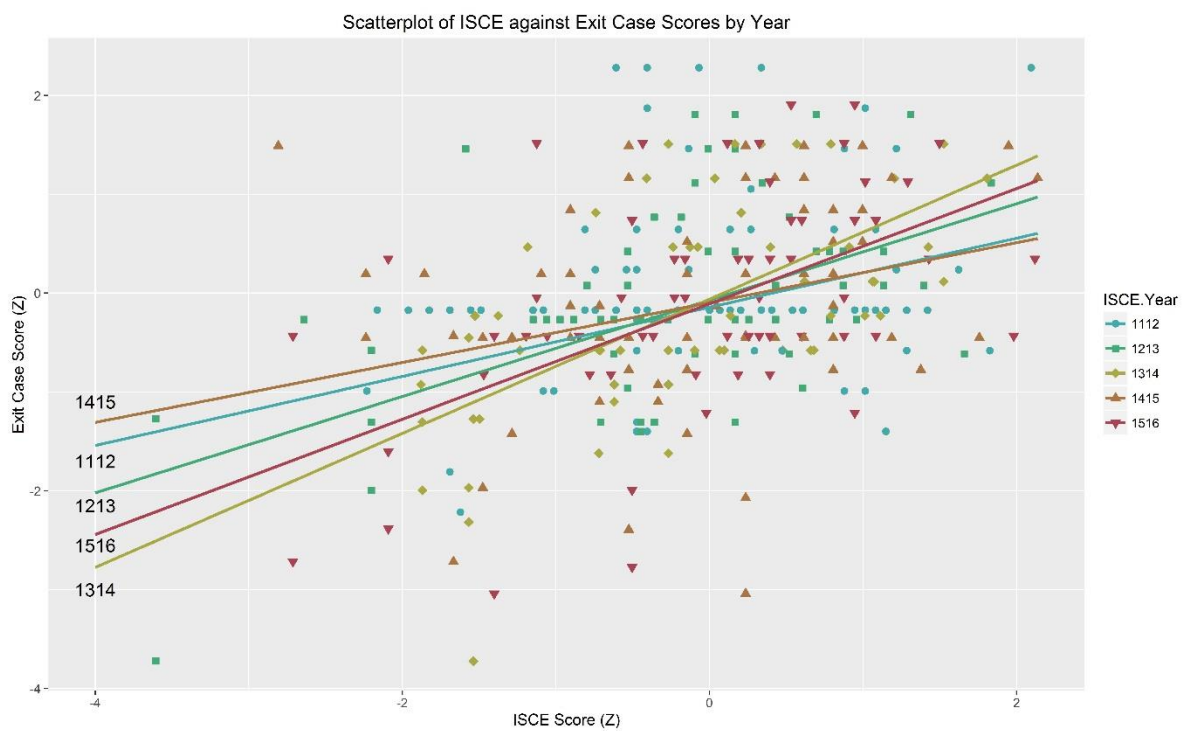
**Table 1 Correlations between Integrated Structured Clinical Examination (ISCE) and Applied Dental Knowledge (ADK) Z-Scores by Year**

Year	df	r	p
1112	90	0.43	<0.001
1213	79	0.37	0.001
1314	60	0.55	<0.001
1415	86	0.30	0.005
1516	68	0.49	<0.001

*Year indicates the academic year in which the ISCE assessment was completed and to which ADK performance was matched. Correlation coefficients (r), degrees of freedom (df), and p-values (p) are shown for each correlation.*

## Correlation between ISCE and Exit Case performance

ISCE (Z-Score within Year) and Exit Case (Z-Score within Year) performance are depicted in Figure 2 and are significantly correlated [ $r_{\text{partial}}(388)=0.43, p<0.001$ ]. The correlations between the two performance measures are also statistically significant for each year individually (Table 2).



**Figure 2 Scatterplot of ISCE Z-Scores against Exit Case Presentation Z-Scores by Year**

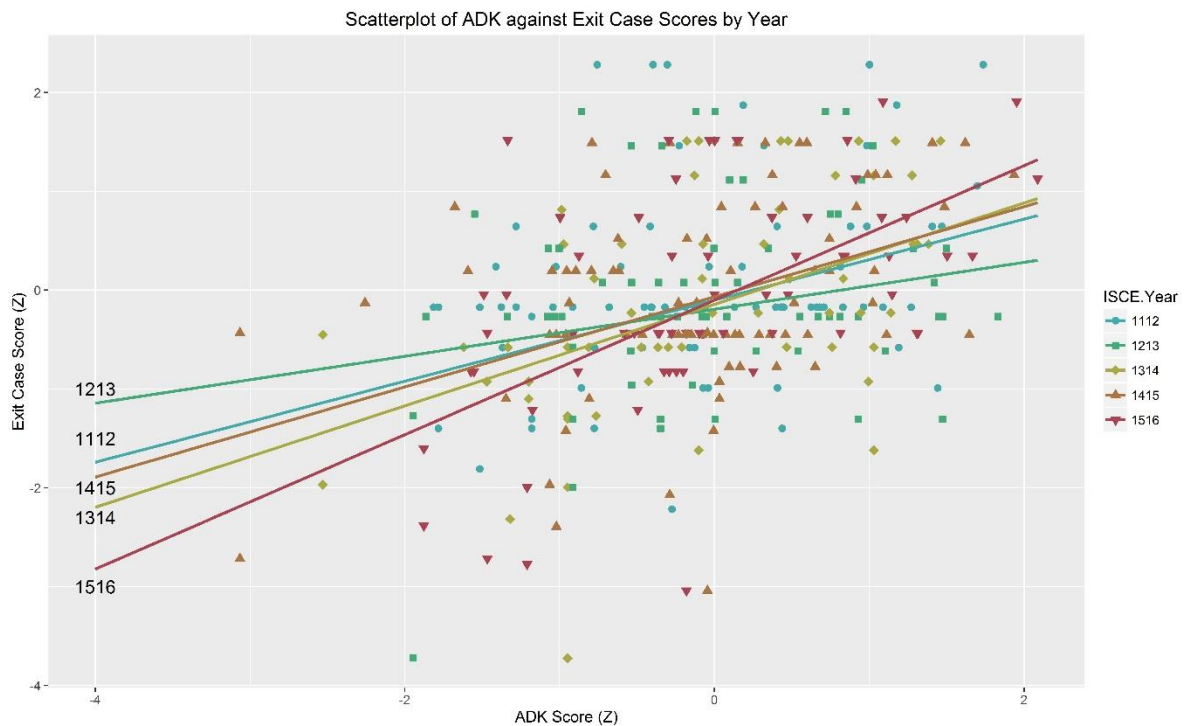
**Table 2 Correlations between Integrated Structured Clinical Examination (ISCE) and Case Presentation (CP) Z-Scores by Year**

<b>Year</b>	<b>df</b>	<b>r</b>	<b>p</b>
1112	90	0.34	0.001
1213	79	0.50	<0.001
1314	60	0.60	<0.001
1415	86	0.28	0.008
1516	68	0.54	<0.001

*Year indicates the academic year in which the ISCE assessment was completed and to which CP performance was matched. Correlation coefficients (r), degrees of freedom (df), and p-values (p) are shown for each correlation.*

### Correlation between ADK and Exit Case performance

ADK (Averaged Z-Score within Year) and Exit Case (Z-Score within Year) performance are illustrated in Figure 3 and are significantly correlated [ $r_{\text{partial}}(388)=0.39, p<0.001$ ]. The correlations between the two performance measures are also statistically significant for each year individually, with the exception of 1213 (Table 3).



**Figure 3 Scatterplot of ADK Z-Scores against Exit Case Presentation Z-Scores by Year**







**Table 3 Correlations between Applied Dental Knowledge (ADK) and Case Presentation (CP) Z-Scores by Year**

<b>Year</b>	<b>df</b>	<b>r</b>	<b>p</b>
1112	90	0.37	<0.001
1213	79	0.21	0.065
1314	60	0.44	<0.001
1415	86	0.40	<0.001
1516	68	0.58	<0.001

Year indicates the academic year in which the ISCE assessment was completed and to which ADK and CP performance was matched. Correlation coefficients (r), degrees of freedom (df), and p-values (p) are shown for each correlation.

### **Predicting ISCE Performance from ADK and Exit Case Performance**

In separate regression models predicting ISCE performance from (a) ADK and (b) Exit Case performance, both ADK [ $R^2_{adj}=0.22$ ,  $F(10,376)=11.83$ ,  $p<0.001$ ] and Exit Case performance [ $R^2_{adj}=0.22$ ,  $F(10,376)=11.79$ ,  $p<0.001$ ] are significant predictors of ISCE performance after controlling for demographic variables.

In a regression model containing demographic predictors and entering ADK and Exit Case presentation performance together, both remain significant predictors of ISCE performance [ $R^2_{adj}=0.28$ ,  $F(11,375)=14.90$ ,  $p<0.001$ ]. This combined model accounts for significantly more variance than either (a) or (b);  $\Delta R^2_{adj}$  significant at  $p<0.001$  in both cases.

No ADK performance and Exit Case performance one-way interaction terms with each demographic factor were significant predictors when added to the above model.

## DISCUSSION

This is one of the few studies exploring the relationship between cognitive and clinical skills examinations amongst final year undergraduate dental students. The results show that performance of final year dental students on applied dental knowledge tests is a significant predictor of their performance on clinical skills examinations, as is their performance on exit case presentations. Furthermore, in combination, ADK and CP performance are significantly related to ISCE performance.

Although statistically significant, these relationships are not so strong as to warrant assessing students with only the ISCE. Rather they serve to show that students combine their dental knowledge and specific clinical skills in the integrated, holistic, high-fidelity simulated setting of the ISCE. This is further supported by the finding that ADK and CP scores in combination account for more variability in ISCE performance than either individually; academic knowledge and clinical skills are used in combination in the ISCE setting.

Our findings could be seen as being consistent with findings from previous studies on dental students. A positive association between OSCE scores and clinical and didactic performance of dental students has been reported.<sup>2</sup> However, this study did not identify any direct correlation between students' scores on OSCE and CP.

Positive correlations are also reported for the written and OSCE examination scores between the final year of the D.D.S/DM.D. program and the results of the National Dental Examining Board of Canada (NDEB).<sup>18</sup> This study also provided evidence of concurrent validity between final year and NDEB examinations. However, similar studies on medical and allied healthcare professionals show that there may be a disparity between academic achievement and performance in clinical settings.<sup>19, 20</sup>

It may be argued that a relationship amongst different methods of assessment may make one or more of the assessments appear redundant.<sup>19</sup> However, each method is aimed at assessing different learning outcomes and serves to enhance the external validity of the assessments.<sup>21, 22</sup> Within the current data although there are commonalities between all three assessments, there are also distinct areas of non-overlap. Furthermore, each of the three assessments are mapped against different learning outcomes for dentists as outlined by the General Dental Council, UK.<sup>14</sup> ADK is primarily aimed at assessing applied dental knowledge while CPs and ISCEs assess a broad range of learning outcomes including: clinical skills; professionalism; communication skills; and management and leadership skills, albeit in different settings. That these should vary between our curriculum and methods of assessment and the programs investigated by these studies is unsurprising, but along with the limited published literature, highlights the need for further research. The aim of future work should be to identify and explore these commonalities, and establish the factors influencing the relationship between academic and clinical performance of dental students both pre- and post-graduation.

Although the present study involved five successive cohorts of undergraduate dental students, our findings are limited to dental students from a single dental school and one curriculum. Therefore, it may not be possible to generalise these findings. It would be worthwhile exploring the relationships between cognitive and clinical skills examinations in other dental schools across the UK and beyond.

Recent studies with medical graduates have shown that performance on integrated assessments during medical school are correlated with performance as a practicing

physician, supporting the value of combining undergraduate assessment scores to assess competence and predict future performance.<sup>23</sup> A recommendation for future research would be to evaluate the students' performance in undergraduate dental programs to predict future performance during dental foundation training in practice settings after graduation. Such research may provide further insights into the acquisition and consolidation of knowledge and clinical skills by dental graduates to inform curricula and assessments in undergraduate dental programs.

## **CONCLUSIONS**

This study provides important information about the relationship between students' performance on cognitive examinations of applied dental knowledge (ADK) and the clinical skills examinations (ISCE and CP) and highlights their predictive value. It also underscores the need to evaluate different methods of assessment in regards to their convergent and divergent validity, and reliability.

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# Appendix 1 Case Presentation Assessment Form Part A



## Case Presentation Grade Form O



2015/16

First Name																														
Last Name																														
ID Number	9						Candidate Number	S		Date		/		/																
Assessor One Name																														
Assessor Two Name																														
Presentation No. <input type="checkbox"/> 1 <input type="checkbox"/> 2																														

Section Grades	Enter one <input checked="" type="checkbox"/> per section			
	Unsatisfactory	Borderline	Satisfactory	Excellent
<i>Section 1</i> Patient History	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Section 2</i> Investigation, Diagnosis and Understanding of Patients Needs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Section 3 Grade</i> Treatment Plan and Justification / Reflection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Section 4 Grade</i> Treatment Provided	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Section 5 Grade</i> Understanding and Evidence	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Section 6 Grade</i> Overall Presentation Skills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Overall Grade	Enter one <input checked="" type="checkbox"/>			
Unsatisfactory	Borderline	Satisfactory	Excellent	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

**P.T.O. TO PROVIDE JOINT FEEDBACK & SIGNATURES**

9	This result is provisional and is subject to validation by the Assessment Panel Academic Year 2015-16
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# Appendix 1 Case Presentation Assessment Form Part B



64913

## Joint Feedback

1) Patient History: Feedback

2) Investigation, Diagnosis and Understanding of Patients Needs: Feedback

3) Treatment Plan and Justification/Reflection: Feedback

4) Treatment Provided: Feedback

5) Understanding and Evidence: Feedback

6) Overall Presentation Skills: Feedback

Assessor 1 Signature:

Assessor 2 Signature:

9