Medical Education

Structured, functional histology practical modules: An answer to medical students' histology nightmare and the way forward for relevant histology instruction in the Indian undergraduate medical curriculum?

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ABSTRACT

Background. It is often a challenge to make histology instruction relevant and interesting. We assessed whether structured, worksheet-based histology practical modules with emphasis on functional histology and clinical application, would improve the learning experience and help students focus on relevant functional and clinical correlates.

Methods. In eight practical sessions, 100 students worked as two groups, one group undergoing new intervention practical modules and another group undergoing the routine laboratory practical exercises as a control group. For every pair of laboratory practical exercises, the groups alternated. Spot tests administered in the following week assessed identification ability as well as application of knowledge. Feedback was collected in the form of written questionnaires from faculty and students, student focus group discussion and in-depth interviews. Analysis of test scores as well as feedback was done.

Results. Test scores were better following the intervention method when comparing the overall score as well as its subcomponents of identification and analysis-type questions ($p < 0.001$). The weaker performers in the class as well as high achievers showed better test scores with the intervention method ($p < 0.001$). Feedback from faculty and students reflected better student experience with the intervention method. Suggestions were made to improve the approach further.

Conclusion. Studying histology through structured modules, which emphasize functional and clinical correlates, appears to improve the identification and application ability of the student as well as the student experience.

Natl Med J India 2020;33:166–71

INTRODUCTION

While the emphasis on histology has decreased in western countries, it has remained a major part of the anatomy syllabus in the Indian medical curriculum for several reasons.[1–3] Histology enables the correlation of structure with function (e.g. knowledge of the structure of various parts of the nephron leads to a better understanding of normal physiological processes occurring in these parts). Second, learning what is normal lays the foundation for understanding the abnormal (e.g. observing the normal glands around eyelashes helps understand the pathophysiology of lid infections in the ophthalmology curriculum). Finally, sometimes, microscopy is the easiest way to study a structure (e.g. visualizing the inner ear).

The Medical Council of India (MCI) recommends that students learn how to identify histological tissue sections as well as correlate the structure with function, as a prerequisite for understanding altered state in disease processes.[4] The literature shows that drawing histology diagrams improves student learning[5] as this makes students less likely to gloss over structural details. However, the authors are concerned that making the diagram the focus of the practical, often leads to side-lining of functional and clinical correlation. For instance, during the study of the eyeball, students look at sections of the optic nerve. They see that the bundles of myelinated axons are covered by the meninges and contain in its substance, the central retinal vessels. However, they often miss the correlation that raised cerebrospinal fluid pressure could damage the optic nerve, and this could manifest as changes in the optic disc. Hence, the application of the histology class is often lost on the student. Moreover, despite the time and workforce dedicated to teaching histology, student feedback (unpublished data) indicates that the majority find the subject difficult and boring.

We aimed to see whether structured, worksheet-based histology practical modules with emphasis on functional histology and clinical application, would simplify the students' approach to identifying tissues, improve their understanding of the functional and clinical correlates, make the experience more enjoyable and be deemed feasible and useful by the faculty.

METHODS

After approval from the Institutional Review Board, informed consent was obtained from 100 MBBS students studying histology at our institution. A two-group comparison model with cross-over was chosen. Before the laboratory sessions, the entire class attended a lecture that covered the functional aspects and clinical correlates in addition to basic histology. In the laboratory session that followed, one of the groups underwent the traditional method (control) while the intervention group undertook structured, functional histology modules. In the traditional method, students studied tissue sections under

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light microscope, drew diagrammatic representations and wrote relevant descriptions in their records. Each group of 10 students was facilitated by 1 faculty member. The intervention practical modules consisted of worksheets providing a step-by-step approach to the slides with questions addressing structure, function and relevant applied aspects that the students would answer in their records. Drawing schematic representations of the slides along with stating two salient identification features formed a component of each worksheet (Table I). The students had individual microscopes but worked in pairs on the questions. Facilitation occurred in the same teacher–student ratio (1:10).

Eight histology sessions spread over the year, were chosen for the study. The 100 students were divided into two groups based on laboratory seating arrangements. These groups were maintained for each pair of histology laboratory sessions. Due to logistic issues relating to laboratory space, division into groups was 40–60 for most sessions, except for the last pair where it was 50–50. Groups were crossed over for the second of each pair of laboratory sessions so that students had equal exposure to both methods.

A spot test was conducted in the week following each laboratory session. Questions consisted of two components: (A) the summative examination requirement of identification of histological tissue sections and stating salient features and (B) questions relating to the functional histology or clinical correlates. Questions were set by the principal investigator but screened for validity by another faculty member. The number of students analysed for each test varied because absentees for either the laboratory session or the test were excluded from the study.

At the end of the first pair of laboratory sessions, preliminary feedback from both faculty and students showed that the intervention modules took a long time to complete. Therefore, for the six subsequent laboratory sessions (three more pairs), the intervention group was provided the practical worksheet immediately after the lecture, to facilitate preparation for the practical.

Comparison of overall test scores as well as performance in the individual subcomponents of the test were done using the Mann–Whitney U test as test results did not have a normal distribution. To determine whether the intervention had an effect on both high and low achievers in the class, participants were stratified based on their histology marks over the entire year into top 85% and lower 15%. The scores of students in these strata were analysed between the control and intervention methods using the generalized linear model. Wald's chi-square test was used to test if the intervention made a significant contribution to the students' scores. A value of $p<0.05$ was considered statistically significant. IBM SPSS version 21 was used for analysis. The first two test scores were included in the analysis because the authors felt the change in methodology was geared to shorten the time taken for the intervention task but did not change the task itself.

At the end of the year, faculty feedback was collected through written feedback questionnaires. Student feedback was obtained by three methods for the sake of data triangulation:[6] (i) written feedback questionnaires with structured and open-ended questions; (ii) a focus group discussion (FGD) with eight student volunteers and (iii) in-depth interviews of five student volunteers.[7] Questionnaire validation was done by expert evaluation involving faculty from the anatomy and medical education departments. Responses to the structured questions in the Likert scale format were treated as ordinal data.[8] Qualitative data obtained from the open-ended questions in the questionnaire were coded and main themes and their frequencies identified. Areas of conflicting information were identified for the FGD and in-depth interviews. Student volunteers were asked to state which practical method they preferred overall. Participants were selected from this group with equal representation from categories of sex, test performance and preference of practical method for FGD and interviews. The FGD was conducted by a faculty member of a different department, to facilitate uninhibited discussion.

RESULTS

Analysis of test performance

Table II shows student performance in each test conducted, as whole, as well as the in the subcomponents of identification and application. In all tests except the first, the intervention group scored significantly higher than the control group. In the identification component of the test, the intervention group scored significantly higher in six out of the eight tests. Scores for the application components showed significantly better performance by the intervention group in all eight tests.

Analysis after stratification of the class into top 85% and lower 15% based on histology performance during the entire year showed both high- and low-performer groups scoring significantly better after the intervention in the tests as a whole and in the individual components ($p<0.001$, Table III).

Figure 1 depicts the results of overall analysis of class scores after adjusting for performance. Scores were higher after the

TABLE I. Sample worksheets for slides studied through the intervention modules

Lymph node	Eyelid
1. Study the given slide; identify the capsule and trabeculae	1. Study the given slide. Identify the external and internal surfaces. What lines them? What epithelium are these made of?
2. Identify the cortex, paracortex and medulla	2. Identify and list the layers of the eyelid
3. How are lymphocytes arranged in the cortex, paracortex and medulla?	3. What is the tarsal plate made of? Name the glands here. What type of glands are they and how are they unique?
4. Identify primary and secondary lymphoid follicles in the cortex	4. Identify the hair follicles of the eyelashes. Name the glands which open into them, stating what type of gland each is?
5. Differentiate primary and secondary lymphoid follicles based on their structure. What is the functional significance of secondary follicles?	5. Which glands are involved in hordeolum externum, internum and chalzion?
6. Trace the pathway of lymph flow through the lymph node. What happens to lymph as it flows through the lymph node?	6. Identify and name the smooth muscle at the base of the tarsal plate
7. What is the function of high endothelial venules?	7. Draw a diagram to represent these structures. State two salient identification features of this slide
8. What could enlargement of regional lymph nodes signify?	
9. Draw a labelled diagram representing what you have seen. List two salient features of identification for this slide	

TABLE II. Comparison of test scores between control and intervention practical groups (Part A: identification component; Part B: application component of test)

Practical (test) number	Category	Control practical	Intervention practical	p value
1	Mean (SD) test score out of 10	6.50 (2.16)	7.47 (1.35)	0.07
Control (*n*=39)	Mean (SD) score Part A out of 5	4.44 (0.83)	4.50 (0.50)	0.68
Intervention (*n*=58)	Mean (SD) score Part B out of 5	2.06 (1.48)	2.98 (0.99)	0.004
2	Mean (SD) test score out of 10	4.11 (2.73)	6.73 (1.86)	<0.001
Control (*n*=55)	Mean (SD) score Part A out of 5	3.12 (1.59)	4.21 (0.80)	0.001
Intervention (*n*=39)	Mean (SD) score Part B out of 5	0.94 (1.40)	2.61 (1.14)	<0.001
3	Mean (SD) test score out of 10	6.36 (1.91)	7.44 (2.26)	0.01
Control (*n*=33)	Mean (SD) score Part A out of 5	4.07 (0.86)	4.03 (1.12)	0.76
Intervention (*n*=53)	Mean (SD) score Part B out of 5	2.27 (1.65)	3.36 (1.57)	0.003
4	Mean (SD) test score out of 10	3.74 (1.83)	7.18 (1.46)	<0.001
Control (*n*=58)	Mean (SD) score Part A out of 5	2.62 (1.10)	4.11 (0.94)	<0.001
Intervention (*n*=33)	Mean (SD) score Part B out of 5	1.00 (1.35)	3.07 (1.04)	0.012
5	Mean (SD) test score out of 10	6.42 (1.81)	8.90 (1.37)	<0.001
Control (*n*=59)	Mean (SD) score Part A out of 5	4.20 (0.76)	4.62 (0.65)	0.02
Intervention (*n*=37)	Mean (SD) score Part B out of 5	2.27 (1.34)	4.24 (1.04)	<0.001
6	Mean (SD) test score out of 10	6.36 (2.46)	8.54 (1.57)	<0.001
Control (*n*=39)	Mean (SD) score Part A out of 5	4.03 (1.30)	4.74 (0.41)	0.003
Intervention (*n*=59)	Mean (SD) score Part B out of 5	2.45 (1.56)	3.83 (1.29)	<0.001
7	Mean (SD) test score out of 10	5.33 (2.38)	8.55 (1.17)	<0.001
Control (*n*=49)	Mean (SD) score Part A out of 5	3.83 (1.51)	4.92 (0.40)	<0.001
Intervention (*n*=45)	Mean (SD) score Part B out of 5	1.50 (1.17)	3.62 (1.02)	<0.001
8	Mean (SD) test score out of 10	5.88 (1.78)	7.87 (1.54)	<0.001
Control (*n*=46)	Mean (SD) score Part A out of 5	3.96 (0.96)	4.61 (0.54)	0.017
Intervention (*n*=49)	Mean (SD) score Part B out of 5	1.93 (1.15)	3.21 (1.24)	<0.001

TABLE III. Analysis of test performance after stratification of the class into high performers (top 85%) and low performers (lower 15%)

Test component	Stratification category	Improvement in test score after intervention	95% confidence intervals	p value
Whole test (out of 10)	High performers	2.34	2.03–2.65	<0.001
	Low performers	2.68	1.79–3.56	<0.001
Identification subcomponent (out of 5)	High performers	0.71	0.59–0.84	<0.001
	Low performers	1.11	0.75–1.48	<0.001
Application subcomponent (out of 5)	High performers	1.64	1.42–1.86	<0.001
	Low performers	1.72	0.98–2.46	<0.001

TABLE IV. Responses to Likert-scale type feedback questions, all values indicate frequency of response, *n*=99

Question	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. The structuring of the practical helped me approach the slides in a more organized manner than usual	0	2	11	38	48
2. Structuring made it easier to identify histological features in the slide	3	3	19	41	33
3. Answering the questions before drawing the slide, made it easier to draw the diagrams	1	5	9	42	42
4. Having to answer questions related to function made the practical more interesting	1	1	17	45	35
5. The structured practical makes it easier to grasp the relevance of histology in the medical curriculum	0	2	15	40	42
6. The time was adequate to complete the practical (exclude the first practical class from your assessment)	4	10	9	41	35
7. Being given the worksheet immediately after the lecture helped prepare for the practical	0	6	5	35	53
8. Working in pairs made the experience more enjoyable	6	16	45	22	10

TABLE V. Summary of responses (n=76) to the open-ended question: 'What did you like about the new type of practical?' on the feedback questionnaire

Theme	Code	Number of responses	Examples of comments in this category	Respondent numbers
Practical format and record work	Answering questions before drawing	6	'Answering the questions before trying to draw helped me understand the slide more thoroughly'	#2, 27, 51, 84, 94, 97
	Diagram easier to draw	10	'Slides were much easier to draw' 'I drew on my own for a change instead of copying my neighbour's diagram'	#3, 15, 22, 38, 50, 62, 63, 73, 84, 97
	Better quality notes	10	'When revising later I felt my notes were better than with the regular practical' 'With the regular practical I'd write my notes in a hurry so that I could leave. With the structured practical questions, I was confident my notes covered the important areas'	#20, 27, 29, 42, 46, 56, 67, 74, 79, 89
			'I didn't always write clinical correlates in my notes in the regular practical'	
Learning	Approach to the slide	6	'Helped me approach the slide in a logical manner' 'Helped me know what to look for'	#1, 22, 23, 28, 38, 98
	Emphasis on what was important	6	'Worksheets focused on what was most important for us'	#11, 12, 20, 80, 82, 94
	Understanding of topic	18	'Better understanding of what I was looking at' 'I felt I understood histo for a change'	#2, 18, 19, 37, 43, 50, 51, 55, 59, 62, 65, 73, 74, 80, 81, 87, 88, 96
	Understanding of the functional and clinical correlates	15	'Functional and clinical questions helped me understand the relevance of histology' 'It was more interesting when I could see the clinical relevance'	#2, 13, 19, 26, 33, 44, 45, 49, 59, 64, 76, 80, 85, 91, 92
Learning behaviour	Coming prepared for class	4	'I soon learnt I could finish faster if I came prepared' 'Forced us to come prepared'	#8, 36, 39, 52
	Self-sufficiency	3	'I could identify things without the tutor showing me' 'I actually drew the diagram on my own'	#63, 65, 88
Student experience	Enjoyment	13	'Functional aspects made it interesting' 'More enjoyable' 'Less boring…still a bit boring though!'	#14, 16, 32, 39, 40, 47, 60, 64, 75, 76, 77, 85, 99
	Engagement	3	'It would make us think. During the regular practical, we would blindly copy our class notes without thinking about it'	#23, 67, 75
	Time-saving in the long run	6	'Once we got used to it, it was much quicker than the regular practical'	#7, 35, 39, 69, 73, 98
	Less tiring	3	'Much less tiring than the regular practical' 'Less tedious than regular histology'	#7, 47, 94
	Working with peers	2	'Discussing with my friend made it easier'	#16, 58
Test experience	Easier to revise for the test	3	'My notes were better to revise for the test'	#17, 30, 56
	Easier to identify slides	4	'Identification was much easier because we had studied the slide in detail'	#5, 28, 68, 87
Other comments	'Broke down complicated slides for us like lymphoid tissue' 'I hate drawing…I liked that there was less emphasis on my drawing as long as I understood the topic'			

intervention module by 2.38 marks, confidence intervals (CI) of 2.09–2.68 ($p<0.001$). In the identification subcomponent, scores after the intervention were higher by 0.76, CI 0.64–0.88 ($p<0.001$). In the application subcomponent, the intervention improved the score by 1.65 marks, CI 1.43–1.86 ($p<0.001$).

Quantitative data from feedback forms

Ninety-nine of the 100 students filled the feedback questionnaires. Table IV shows data from the questions in the Likert scale format. Figure 2 represents data from questions where a preference had to be stated.

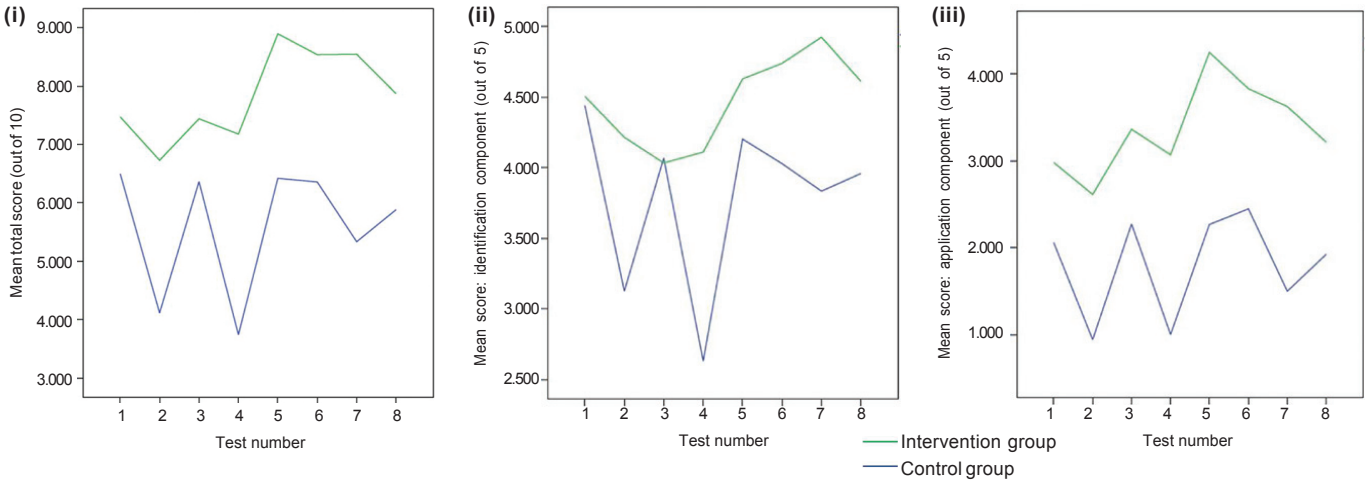

FIG 1. Comparison of test performance following both types of practicals with regard to (i) overall test scores; (ii) identification component; and (iii) application component

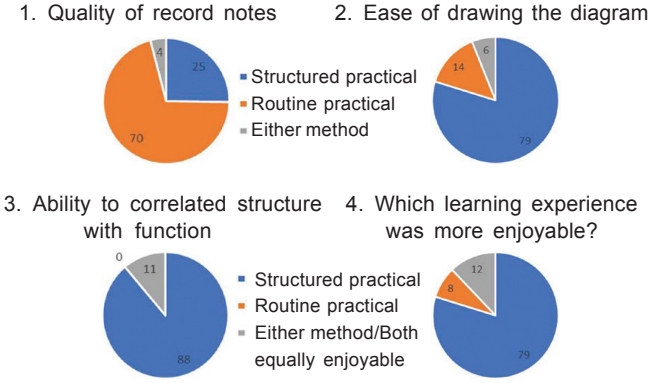

FIG 2. Pie charts showing responses to the section in student feedback questionnaire: 'Compare your experiences with the two types of practicals and indicate your preference'

Qualitative data

The faculty feedback (n=12) was largely in favour of the new method. Faculty universally felt the intervention resulted in deeper student learning, better preparedness for the practical, greater self-sufficiency in class and improved the quality of record notes. However, concern was raised that this method did not encourage the skill of writing a descriptive paragraph, which was inbuilt into the control method.

Information from student feedback forms. Open-ended questions regarding what students liked and disliked about the intervention were answered by 77 and 39 students, respectively (Tables V and VI).

Information from FGD. There was consensus that the intervention helped students identify slides and understand functional and clinical correlates better. All participants felt competent after the intervention to fulfil the summative

TABLE VI. Summary of responses (n=39) to the open-ended question: 'What did you dislike about the new type of practical or what could be done better?' on the feedback questionnaire

Theme	Number of responses	Examples of comments in this category	Respondent numbers
Shorter questions	4	'Shorter questions so we can finish faster' 'Ask questions with more concise answers to save time'	#1, 23, 73, 76
More time to prepare for the practical	10	'Bigger gap between lecture and practical' 'Using the lunch break to prepare for the practical was not great'	#3, 40, 43, 52, 58, 59, 67, 79, 82, 95
Notes felt incomplete	5	'I preferred writing a paragraph for my notes' 'My notes felt incomplete because I was only answering the specific questions'	#5, 7, 33, 60, 77
Time taken	5	'Initially, this took me much longer to complete, it got better with time' 'Practicals with more than four slides may not finish on time'	#12, 14, 45, 55, 84
Introduce this for more practicals	8	'I wish we had this for all central nervous system slides' 'Definitely need to introduce for difficult topics'	#11, 13, 15, 22, 26, 32, 74, 89
Working with peers	1	'I'd rather work on my own'	#87
Other suggestions		'Including pathology slides for comparison would have made it even more interesting' 'Allow us to answer (the worksheet) before the practical to save time' 'Cannot we scrap the diagram altogether?' 'Do not change anything. It was great like this' 'I did not like that the whole class was not doing the same thing' 'Introduce writing notes before diagram for all pracs' 'It feels too formal and organized'	

examination requirements. Although answering the questions took time initially, during the later practicals, the students could finish faster than the control group, provided they came prepared. A major difference was expressed regarding the notes produced. The notes with the intervention were more specific and covered important points.

However, two individuals in the group felt that these notes were less elaborate than with the control. The suggestion was to allow for additional notes to be added after the worksheet was completed.

Information from in-depth interviews. Responses from the in-depth interviews echoed other feedback received. All interviewed students found the structured format encouraged deeper learning of the functional and clinical correlates and the format helped them approach the slides in a more organized fashion. Four of the five students preferred the notes written in the question–answer format stating the most important points were covered, but one stated preference for unstructured notes.

DISCUSSION

Providing a clinical context to learning has been shown to be helpful in most basic science education including histology.[9–12] The results of this study showed similar findings. While the literature shows that drawing diagrams improves learning in histology,[5] in this intervention, the diagram formed a part of and was not the main focus of the laboratory exercise. Rather, the focus was shifted to correlating structure with function and the clinical application of histology. Despite this emphasis on the application and functional correlates, the results showed an improvement in both identification and application components of the tests. In fact, the only tests where the two groups showed equal performance in identification were those, in which the slides being tested were remarkably different from each other—practical 1: (i) compact bone ground sections; (ii) spongy bone haematoxylin and eosin sections; (iii) developing bone Luxol fast blue stain; practical 3: (i) placenta section under light microscope and (ii) umbilical cord under dissection microscope. It was also encouraging to note that the improvement in test performance following the intervention module was seen in both low- and high-performer groups in the class.

It could be argued that the facilitator–student ratio of 1:10 is not universally feasible. However, the feedback from faculty indicated that because the intervention method included a step-by-step approach to the slide, students were more self-reliant. It would, therefore, be possible to implement this with fewer faculty. In addition, both faculty and student feedback indicated that the intervention induced better preparedness for the laboratory sessions.

Feedback from faculty and students showed that the majority preferred the notes written during the intervention modules. However, some did raise concerns about the brevity of notes and a feeling of lack of completion. It is suggested, therefore, that students be encouraged to add notes of their own after completing the worksheet. This would also be practice for the short note component of the summative written examination. It is well known that assessment plays a key role in driving student learning.[13] It is therefore suggested that if assessments in histology were to focus more on the application of the basic sciences than pure recall of fact, the students would learn these applications better.[14]

The Vision 2015 document produced by the MCI[15] had outlined five key roles of the Indian medical graduate as that of a clinician, a leader and member of the healthcare team, communicator, life-long learner and professional. Themes emerging from the student feedback regarding this intervention show attributes that fit into each of these roles.

Conclusion

We suggest that structured, histology modules with emphasis on the functional and clinical correlates provide a way to make histology more relevant in the undergraduate anatomy curriculum. We also suggest that formative and summative assessments place as much emphasis on the testing of functional histology and clinical application as the identification of histological tissue sections.

ACKNOWLEDGEMENTS

We would like to thank Dr Vinay Timothy Oommen, Associate Professor, Department of Physiology, Christian Medical College, Vellore, for conducting the FGD for this study and compiling the data from the same. This project was funded by an institutional research grant.

Conflicts of interest. None declared

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