Three dimensional Bone Models Help in Improving the Performance of Orthopaedic Postgraduates on Fracture Fixation

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ABSTRACT

Introduction: Fracture fixation is the most common procedure performed by Orthopaedician. Objective: The main objective of the study is to train the postgraduates in fracture fixation using a skills lab, to have an idea about the establishment of a skills lab, to weigh the pros and cons of establishing a functional skills lab and also to evaluate scientifically the beneficial effects of both cognitive and psychomotor skills on a quantitative scale.

Methods: It is a Quantitative Interventional study in which eight postgraduates of first-year Orthopaedics participated in seven sessions of different modules at Maharajah's Institute of Medical College, Nellimarla, Vizianagaram district, Andhrapradesh. The study uses assessment tools like Multiple Choice Question (MCQs) and Objective structured practical examination (OSPE) questionnaire.

Results: From the results, it was found that the scores obtained in the post-workshop either in MCQs pattern or OSPE questionnaire pattern for testing knowledge were higher among all the eight postgraduate students comparatively than the scores obtained during the pre-workshop training programme and the obtained results were highly significant as the p-value was less than 0.05. The results of the current study had proved that the skills of all the eight postgraduate students were very well improved from the pre to post-workshop on various modules. It was concluded that OSPE can supplement the existing pattern of conventional methods of clinical examination.

Conclusion: In the present scenario, it may be realistic to expect its inclusion in the formal summative evaluation schedule of medical colleges and in the day-to-day assessment of students to improve their clinical competence. The surgical simulation training program on various cognitive and skills modules gained a step forward in the development of a comprehensive orthopaedic surgical skills educational curriculum.

Key Words: Fracture fixation, Trauma, Skills lab, Postgraduate training, OSPE questionnaire, Surgical skills

INTRODUCTION

The primary aim of postgraduate education is to develop professionals who can provide outstanding health care while also furthering science through study and training. Various congenital, developmental, infective, traumatic, inflammatory, metabolic, degenerative, neuromuscular, and oncologic disorders of the musculoskeletal systems should be defined and understood by a postgraduate undertaking training MS in Orthopaedics. She or he should be capable of providing skilled nursing services to trauma and orthopaedic patients in primary, secondary, and tertiary care settings. During the first year of the MS Orthopaedics

programme the students should learn and develop many skills and one such is to perform on bone models, inter-fragmentary compression screws, external fixation, Tension band wiring and Broad plating etc. It is believed to be significant that the student learning three-dimensional orthopaedic models and, meanwhile acquiring knowledge how to practice them to develop a creative skill to reconstruct them is one of the main motives in the Postgraduate curriculum programme. The advancement in the scientific technology of constructing the three-dimensional models and connecting to the research field is being endorsed. Gaining practical skills is a disparagingly significant area in surgical training programmes. At present, the progress of

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orthopaedic students in acquiring surgical skills is assessed through faculty evaluations and case logs.^{1,2}

Assessment of Psychomotor skills of the Postgraduate student in Orthopaedics is not present in the existing curriculum in India. The Postgraduate student's knowledge (cognitive domain) only is assessed as per our existing curriculum. Fracture fixation is the most common surgical procedure carried out by Orthopaedic surgeons. Postgraduate surgical training is facing significant challenges following the advent of limitations on working hours.^{3,4}

From the literature survey, the author had found that there were no previous studies related to the present work and the study was reported for the first time by the authors. The main objectives of the present study were to assess the psychomotor skills especially stereognosis, hand eye co-ordination as well as an understanding of the usage of instruments, implants and the knowledge of fracture fixation and to check the feasibility of skills lab and to have a rough idea about the minimum requirements of material, money, manpower and minutes for an effective skills lab module.¹ The study also focused on the comparison of pre-workshop to post-workshop performance of both cognitive (knowledge) and psychomotor skills in First-year postgraduate students of Orthopaedics after workshop training using 3D artificial synthetic models(shinbone). The study uses assessment tools Multiple Choice Question (MCQs) and Objective structured practical examination questionnaire to meet the deficiencies of the conventional system of practical/clinical examination of medical students. Objective Structured Practical Examination (OSPE) is a method of objectively testing the clinical and practical knowledge and skills acquired during the medical curriculum. This method was standardized by the All India Institute of Medical Sciences.

MATERIALS AND METHODS

The study was carried in Maharajah's Institute of Medical Sciences, Nellimarla, Vizianagaram, Andhrapradesh, India during the period from Sep 2017 to Nov 2017. It is a quantitative interventional study conducted after getting the protocol approved by the Institutional Ethics Committee in which eight postgraduates of the first year Orthopaedics participated in seven sessions of different modules to include Screw fixation, Lag screw fixation, Tension band wiring fixation, Dynamic hip screw fixation, Proximal femoral nail fixation, External fixator fixation and Plate fixation. Each topic is allotted 3 days in prior advance and MCQ(Multiple Choice Question) scores of pre-workshop to post-workshop were assessed with the fixed questionnaire of 10 MCQ'S to assess knowledge. Objective Structured Practical Examination (OSPE) scores of practical sessions were done through pre-demonstration to post- demonstration to assess the psy-

chomotor skills and marks were graded on a scale of 10 by a separate senior faculty. The questionnaire was designed based on other previous studies. Pre-workshop scores were obtained for a maximum of 10 marks each for knowledge by MCQs and Psychomotor skills by fracture fixation on Synthetic bone (Synbone) which were compared after a workshop consisting of lecture for teaching knowledge and demonstration by the author to teach psychomotor skills. Post-workshop assessment for a maximum of 10 marks each for knowledge by MCQs and Psychomotor skills by fracture fixation on Synthetic bone (Synbone) was done for comparison to pre-workshop. Statistical analysis is done by paired t-test and separate p-values for knowledge and psychomotor skills were obtained.

Statistical analysis

Data were analyzed using the SPSS software (Ver. 24; SPSS Inc., USA). Analysis of variance (ANOVA) tests was used to determine the significant differences between treatments at $p < 0.05$ using Tukey's HSD test.

RESULTS

The study was designed to be conducted in different steps and it was started initially through a pretest conducted in 7 different modules on eight postgraduate subjects. It was a knowledge-based testing study. This was followed by the demonstration by the author involving videos and lectures on 3D dimensional bone models for 30 min. Again a post-test was conducted on eight postgraduate subjects on all the seven sessions of different modules. The seven sessions of different modules for the pre-test and post-test evaluation include Screw fixation, Lag screw fixation, Tension band wiring fixation, Dynamic hip screw fixation, Proximal femoral nail fixation, External fixator fixation and Plate fixation. Each questionnaire containing 10 MCQs and the results in terms of percentages were depicted in Table 1 to Table 7 for all the seven different modules. From Table 1, it was depicted that the score percentage for the module screw fixation was highly improved from the pre-test to post-test evaluation. Subjects S4, S7 and S8 secured the highest percentage on this psychomotor skill. Table 2 showed that the score percentage for the module lag screw was enhanced from the pre-test to post-test evaluation of 8 subjects. Subjects S1, S2 and S7 secured the highest percentage of 100% on this psychomotor skill. Table 3 represented the score percentage for the module tension band wiring was higher from the pre-test to the post-test evaluation of 8 subjects. All the Subjects except S5, S6 and S8 secure 90%. Table 4 showed that the score percentage for the module dynamic hip screw vs proximal femoral nail was higher from the pre-test to the post-test evaluation of 8 subjects. All the Subjects except S7 secured a 90% percentage. Table 5 showed that the score percentage

for the module proximal femoral nail vs. dynamic hip screw fixation was higher from the pre-test to the post-test evaluation of 8 subjects. All the Subjects secure 100% percentage. Table 6 depicted the score percentage for the module external fixator. It was noticed that from the pre-test to a post-test evaluation in all the 8 subjects the score was increased at higher ratios and all the subjects secure 100% percentage. From the Table 7, it was depicted that the score percentage for the module plate fixation was highly improved from the pre-test to post-test evaluation. All the subjects achieved 100% on this psychomotor skill.

From Figure 1, it was observed that the scores obtained in the OSPE on screw fixation post-workshop were higher in all the 8 postgraduate students. However, in subject 2, the score was lesser than the score obtained in the post-workshop MCQs for testing knowledge. Subjects 4, 7 and 8 had acquired similar scores on OSPE and MCQs screw fixation post-workshop. However significant p-value results were obtained on MCQs and OSPE pre to post-workshop are 0.000 and 0.004 respectively in the screw fixation module. Figure 2 depicted that, the scores obtained in the OSPE on lag screw fixation post-workshop were higher in all the 8 postgraduate students except subject 7 the score was lesser than the score obtained in the post-workshop MCQs for module 2. Subject 1 and subject 2 achieved similar scores on OSPE and MCQs screw fixation post-workshop. Subject 2 performed very well during the pre and post-workshop and achieved somewhat similar results. The p-values of MCQ's and OSPE pre to post-workshop were 0.006 and 0.000 respectively for the lag screw fixation module and were significant. From Figure 3, it was showed that the scores obtained on MCQs on screw tension band wiring post-workshop were

higher in all the postgraduate student subjects 1,2,3,4 and 8. However in subjects 5, 6 and 7 the scores obtained were equal on OSPE and MCQs post-workshop module 3. The p-value of MCQs and OSPE pre to post-workshop were 0.001 and 0.000 respectively for the tension band wiring module and were significant. From Figure 4, it was noticed that the scores obtained on MCQs on dynamic hip screw module post-workshop were higher in all the eight post-graduate student subjects comparatively than the other scores. The p-value of MCQs and OSPE pre to post-workshop were 0.000 and 0.0001 respectively for the dynamic hip screw module and were significant. Figure 5 showed that the scores obtained on MCQs on proximal femoral nailing post-workshop were higher in all the eight post-graduate student subjects comparatively than the other scores. The results were highly significant and the p-values of MCQs and OSPE pre to post-workshop were 0.000 and 0.003 respectively for the proximal femoral nailing module. From Figure 6 it was observed that the scores obtained in MCQs and OSPE post-workshop on external fixation module were higher than the scores obtained in the MCQs and OSPE pre-workshop results. The results were significant in terms of p-value on MCQ's and OSPE pre to post-workshop and were 0.000 and 0.003 respectively for the external fixation module. From Figure 7 it was noticed that the scores obtained on MCQs on plate fixation module post-workshop were higher in all the eight postgraduate student subjects comparatively than the other scores. The results were significant as the p-values of MCQ's and OSPE pre to post-workshop were 0.000 and 0.000 respectively for the plate fixation module. The results of the current study had proved that the skills of all the eight postgraduate students were very well improved from the pre to post-workshop on various modules.

Table 1: Pre-test and Post-test evaluation of subjects-Screw Fixation

The questionnaire with 10 MCQs on screw fixation	Subjects	Pre-test score	Post-test score
1. Finest thread pitch is seen in	S1	50%	90%
2. The core size of a screw defines the size of which instrument	S2	60%	90%
3. Size of the drill bit to be used for the pilot hole of cortical screw size 4.5mm is	S3	10%	70%
4. Size of drill to be used for the pilot hole of cortical screw size 3.5mm is	S4	40%	100%
5. Size of tap to be used for 4.5 mm cortical is	S5	30%	70%
6. Size of tap cortical screw 3.5 mm is	S6	30%	80%
7. Difference between cortical screw 4.5 mm and malleolar screw 4.5 mm	S7	20%	100%
8. Screw converts	S8	40%	100%
9. Ideal bit for a 6.5 mm cancellous screw is			
10. Most common shape of head recess for the bone screw is			

Table 2: Pre-test and Post-test evaluation of subjects: Lag screw

A questionnaire with 10 MCQs on the Lag Screw module	Subjects	Pre-test score	Post-test score
1. Position of the lag screw concerning fracture plane required is	S1	80%	100%
2. Lag screw functions by _____ the fracture fragments	S2	100%	100%
3. Type of fixation achieved with lag screw is	S3	70%	80%
4. Near cortex needs to be _____ to attain lag function	S4	70%	70%
5. Glide hole needs to be drilled to the size of	S5	50%	80%
6. Glide hole and thread hole needed for 4.5 mm cortical screw to act as lag are	S6	40%	70%
7. Drill bit required for 6.5 mm partially threaded cancellous screw for lag effect is	S7	70%	100%
8. Drill bit used for gliding and threaded hole of a 3.5 mm cortical screw are	S8	60%	80%
9. Drill bit for threaded hole of 4.0 mm partially threaded cancellous screw is			
10. Instrument used for creating a platform for the head is			

Table 3: Pre-test and Post-test evaluation of subjects: Tension Band Wiring

The questionnaire with 10 MCQs on the Tension Band Wiring module	Subjects	Pre-test score	Post-test score
1. Tension band converts	S1	60%	100%
2. Static tension band is seen at	S2	90%	100%
3. To achieve tension band effect plate should be fixed on _____ surface of the femur	S3	80%	100%
4. Tensile side for the shaft of the radius is	S4	30%	100%
5. Tension band wiring is the technique of	S5	40%	90%
6. Bones Young's modulus of elasticity is nearest to	S6	30%	90%
7. Galvanic corrosion is due to	S7	30%	100%
8. International standard organization for testing materials for orthopaedic use is	S8	30%	90%
9. Most common stainless steel used in orthopaedic implants is			
10. Strongest construct with 2 k-wires for lateral condyle fracture of the humerus is			

Table 4: Pre-test and Post-test evaluation of subjects: Dynamic hip screw vs Proximal femoral nail

The questionnaire with 10 MCQs on Dynamic hip screw and PFN	Subjects	Pre-test score	Post-test score
1. Choice of implant for reverse oblique fracture is	S1	50%	100%
2. End cap is used in	S2	50%	100%
3. Highest rotational stability of proximal fragment is seen with	S3	60%	100%
4. Fretting corrosion is due to	S4	40%	100%
5. Rate of deformation is	S5	70%	100%
6. Reverse Z-effect is seen with	S6	40%	100%
7. Hypertrophic non-union is due to	S7	20%	90%
8. Herzog bend is located at	S8	30%	100%
9. Guard criteria are for			
10. Rotational stability in the nail is increased by			

Table 5: Pre-test and Post-test evaluation of subjects: Proximal Femoral Nail Vs Dynamic hip screw fixation

The questionnaire with 10 MCQs on Proximal Femoral Nail Vs DHS	Subjects	Pre-test score	Post-test score
1. Dead bone surrounded by granulation tissue is	S1	50%	100%
2. Cloverleaf nail is	S2	50%	100%
3. Reaming is contraindicated in	S3	50%	100%
4. Strength of nail can be improved maximum by	S4	20%	100%
5. The quadrant with the highest chance of failure of DHS screw is	S5	30%	100%
6. Length of the DHS guide wire is	S6	50%	100%
7. (Xap x Dtrue/Dap) +(X lat x Dtrue/Dlat) is	S7	60%	100%
8. Oxinium is Oxidised	S8	40%	100%
9. Choice of the nail in suspicion of infection is			
10. Cold welding is seen mostly with			

Table 6: Pre-test and Post-test evaluation of subjects: External Fixator

The questionnaire with 10 MCQs on External Fixator	Subjects	Pre-test score	Post-test score
1. Weakest link in the mechanical stability of external skeletal fixation is	S1	60%	100%
2. Which of the following techniques increases strength and stability to an external fixation construct	S2	60%	100%
3. Bone remodels in response to mechanical stress	S3	50%	100%
4. Choice of the pin in osteoporotic bone for skeletal traction is	S4	40%	100%
5. Horse hoof is a type of	S5	60%	100%
6. JESS fixator is for	S6	40%	100%
7. Implant of choice for Damage control in orthopaedics is	S7	40%	100%
8. Periosteal blood supply is least damaged with	S8	50%	100%
9. Glyocalyx formation is lowest over implants made of			
10. DASH score is for			

Table 7: Pre-test and Post-test evaluation of subjects: Plate Fixation

The questionnaire with 10 MCQs on Plate Fixation	Subjects	Pre-test score	Post-test score
1. Hydroxyapatite coating of Schanz pin helps in	S1	60%	100%
2. Internal fixator is	S2	50%	100%
3. How does a dynamic compression plate achieve compression at the fracture of long bone	S3	90%	100%
4. Which of the following best describes the 25-year -old's femur when compared with the radiograph of a healthy 85-yr old female?	S4	60%	100%
5. What kind of bone healing occurs in 25 yr-old male with ORIF with rigid compression plating for transverse fracture humerus	S5	50%	100%
6. Fiat-are staging is for	S6	40%	100%
7. Strongest part of vertebrae is	S7	90%	100%
8. Commonest complication of colles fracture is	S8	60%	100%
9. Most common complication of ex.fixator is			
10. Alocked plate used in a bridge plate fashion is biomechanically most similar to which of the following fixation methods

Figure 1: Comparison of scores obtained in MCQs and OSPE questionnaires in module 1 of eight different post graduate subjects.

Figure 4: Comparison of scores obtained in MCQs and OSPE questionnaires in module 4 of eight different postgraduate subjects.

Figure 2: Comparison of scores obtained in MCQs and OSPE questionnaires in module 2 of eight different post graduate subjects.

Figure 5: Comparison of scores obtained in MCQs and OSPE questionnaires in module 5 of eight different postgraduate subjects.

Figure 3: Comparison of scores obtained in MCQs and OSPE questionnaires in module 3 of eight different postgraduate subjects.

Figure 6: Comparison of scores obtained in MCQs and OSPE questionnaires in module 6 of eight different postgraduate subjects.

Figure 7: Comparison of scores obtained in MCQs and OSPE questionnaires in module 7 of eight different postgraduate subjects.

DISCUSSION

The present surgical simulation training program consisting of a cognitive and skills module represents a step forward in the development of a comprehensive orthopaedic surgical skills educational curriculum. At present, the most substantial barrier to the adoption of surgical skills laboratories and a formalized surgical skills curriculum is the lack of funding. All the modules showed significant improvement in p values after the workshop in terms of both cognitive and psychomotor skills to the 1/1000th value implying the advantage of the skills lab.

Skills lab and these workshops give a chance to experiment and correct the mistakes while learning without harming the patients it shows an iatrogenic fracture occurs at the time of screw insertion. It gives hands-on experience to the participants and builds confidence. Participants can learn to correct mistakes without causing harm to the patients. It makes learning more realistic and improves the skills of participants and early acclimatization to the use of instruments. Early hands-on exposure will orient them to real-life scenarios. The study strongly recommends the need for a skills lab in improving the psychomotor skills of participants and to correct the mistakes without harming the patients.

CONCLUSION

It was concluded that OSPE can supplement the existing pattern of conventional methods of clinical examination. In the present scenario, it may be realistic to expect its inclusion in

the formal summative evaluation schedule of medical colleges and in the day-to-day assessment of students to improve their clinical competence. The surgical simulation training program on various cognitive and skills modules gained a step forward in the development of a comprehensive orthopaedic surgical skills educational curriculum. This training programme gives hands-on experience to the participants specifically postgraduate students to build their confidence levels and learns to correct their mistakes without causing harm to the patients. Hence it is highly advised for the need of skills lab in improving the psychomotor skills.

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Authors' Contribution: The main author of the study AS had performed the work, wrote the first draft of the manuscript. Author SAV collected the literature and corrected the manuscript. Author PVL performed the statistical part of the work.

Ethical clearance: This study was reviewed and approved by The Ethics Committee of Maharajah's Institute of Medical Sciences, Nellimarla, Vizianagaram, Andhrapradesh, India.

REFERENCES

1. Karam MD, Kho JY, Yehyaw TM, Ohrt GT, Thomas GW, Jonard B et al. Application of surgical skill simulation training and assessment in orthopaedic trauma. *Int Orth J*. 2012;32:76–82.
2. Karam MD, Westerlind B, Anderson DD, Marsh JL. Development of an orthopaedic surgical skills curriculum for the postgraduate year one resident learners. University of Iowa experience. *IOJ*. 2013; 33:178–184.
3. Ananthakrishnan N. Objective structured clinical/practical examination (OSCE/OSPE). *JPM*. 1993 Apr 6; 39 (2):82-84.
4. Shankar RP, Dubey AK, Mishra P, Deshpande VY, Chandrasekhar TS, Shivanda PG. Student attitudes towards communication skills training in a medical college in Western Nepal. *EH (Abingdon)*. 2006 Mar; 19(1):71-84.