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# PATHOGROSS: A QUALITY IMPROVEMENT INITIATIVE TO ENHANCE EFFICIENCY, SAFETY, AND WORKFLOW IN HISTOPATHOLOGICAL GROSSING – A PROSPECTIVE INTERVENTIONAL COMPARATIVE STUDY

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## ABSTRACT

**Background:** Grossing is a critical step in histopathology that directly influences diagnostic accuracy, specimen handling, and turnaround time. Conventional grossing boards lack integrated features for measurement, organization, and instrument handling, leading to workflow inefficiencies and increased processing time. To address these limitations, a quality improvement intervention was developed in a modified grossing board (PATHOGROSS).

**Objective:** It is to design, develop, and evaluate the effectiveness of the PATHOGROSS modified grossing board in improving workflow efficiency, measurement accuracy, specimen organization, and turnaround time in histopathological grossing.

**Methods:** This prospective within-subject crossover interventional comparative study was conducted over one year in a tertiary care pathology laboratory. Fifteen operators performed standardized grossing procedures on 60 surgical specimens using both conventional and PATHOGROSS boards, serving as their own controls. Workflow parameters assessed included turnaround time, measurement accuracy, cassette handling, instrument handling, and overall workflow efficiency using a 5-point Likert scale. Statistical analysis was performed using paired t-test and Wilcoxon signed-rank test, with $p < 0.05$ considered significant.

**Results:** The PATHOGROSS board showed improvement in all parameters measured. The mean time to completion was reduced from $20.42 \pm 9.27$ minutes with the standard board to $9.55 \pm 3.89$ minutes ($p < 0.001$). Measurement accuracy improved from $2.50 \pm 0.50$ to $4.50 \pm 0.50$, cassette handling from $2.00 \pm 0.00$ to $4.50 \pm 0.50$, instrument handling from $1.00 \pm 0.00$ to $5.00 \pm 0.00$, and workflow efficiency from $2.97 \pm 0.90$ to $4.43 \pm 0.50$ (all $p < 0.001$). All cases using PATHOGROSS achieved high-performance grading compared to predominantly low-to-moderate performance with the conventional board.

**Conclusion:** The PATHOGROSS modified grossing board increases the speed of grossing, reduces turnaround time, and leads to better specimen organisation and measurement accuracy in gross histopathological. Its integrated features provide a practical yet efficient solution for increasing the productivity of the laboratory, particularly in high-volume settings.

**KEYWORDS:** Histopathology grossing; workflow efficiency; turnaround time; quality improvement; surgical pathology; laboratory ergonomics

## INTRODUCTION

Grossing in histopathology refers to the macroscopic examination, description, measurement, and dissection of surgical specimens to obtain representative tissue sections for microscopic evaluation, thereby forming a critical link between specimen collection and definitive diagnosis (1,2). Through systematic gross examination, important pathological features such as tumor margins, lesion characteristics, and tissue involvement can be identified, which directly influence diagnostic accuracy, disease staging, and subsequent clinical management (3,4). The procedure involves proper orientation, measurement, sampling, and documentation with the aim of preserving and maintaining the tissue architecture for better microscopic assessment (5). Any compromise during this stage may result in sampling errors or diagnostic inaccuracies, ultimately impacting patient outcomes.

The grossing board is the primary working platform used for specimen dissection, providing a stable surface for measurement, cutting and handling of tissues (6). But in practical histopathology, conventional grossing boards can have various limitations, such as a lack of measurement guide, surface damage due to repeated scalpel use, difficulty in maintaining cleanliness, and specimen instability during cutting (7,8). Moreover, the ergonomic limitations and lack of integrated organizational characteristics can contribute to an inefficient workflow, particularly in high-volume laboratories, where several specimens can be handled at the same time. These limitations may result in longer turnaround times, lower efficiency and more chances of specimen handling errors, which explains the necessity of an improved workstation (9).

Although the development of grossing stations has been enhanced by technological advancements, which include ventilation and improved lighting, the design of the grossing board itself has remained largely similar and still serves to provide a simple cutting surface (6,7). Literature presents problems with the markings on measurements that fade,

imprecise cassette location, and lack of a safe way to hold the blades, which may decrease productivity and safety in the laboratory (8,9). Considering the critical importance of grossing in histopathological diagnosis, there is limited focus on the development of integrated grossing boards that offer accuracy of measurement of specimen, specimen organisation and safety on a single platform.

To address these limitations, a modified grossing board, PATHOGROSS, was developed as a complete solution to improve specimen handling, accuracy of measurement, and workflow efficiency. The design also includes a laser-etched scale of measurements, labelled cassettes holding spaces and a magnetic docking space for instruments, which allows a more organized and safer approach to handling instruments during grossing processes. The rationale behind this intervention is that specimen organization, accurate measurement, and improved instrument management can help minimize the chances of specimen misidentification, minimize handling errors, and improve operator efficiency. Moreover, the application of durable and medical-grade materials is designed to enhance resistance to chemical contact and surface integrity, which will facilitate hygiene and longevity (10,11). The PATHOGROSS board can reduce the need for external assistance and ensure efficiency in the histopathology laboratories by reducing the need to seek external assistance and ensuring precise measurements (12).

Accordingly, the present study aimed to design, develop, and evaluate this modified pathological grossing board as a quality improvement intervention in routine histopathology practice.

## MATERIALS AND METHODS

### Study Design and Setting

The proposed within-subject crossover interventional comparative study was conducted at the Department of Pathology, Saveetha Medical College and Hospital, Chennai, a tertiary care center, during one year, i.e., between January 2024 and January 2025. Ethical approval was obtained prior to commencement of the study, and the trial was registered. The research process was divided into two steps: the design and development of the PATHOGROSS board and subsequent manufacturing, testing and workflow analysis. The clinical assessment phase employed a crossover design where each participant conducted the grossing activities with both the traditional grossing board and the PATHOGROSS board, thus serving as their own control.

### Participants (Operators) and Specimens

15 participants (histotechnologists and pathology postgraduate trainees) who had previous experience with routine grossing were enrolled. A total of 60 large surgical specimens that needed standard grossing were used. Small biopsy specimens (e.g., skin biopsies, endometrial pipette biopsies, endoscopic biopsies) were excluded to avoid procedural uniformity and similar task complexity.

### Intervention: PATHOGROSS Grossing Board

The intervention was the implementation and development of a modified pathological grossing board (PATHOGROSS), which was created by computer-aided design and produced with the help of CNC machining. This board featured an integrated laser-cut scale (0-30 cm), labeled cassettes containing a grid (2 x 10 grid), a magnetic blade docking area, a non-slip bottom, and modular mounting characteristics (figure 1). These factors were guided towards better specimen treatment, safety and accuracy of measurements of operators.

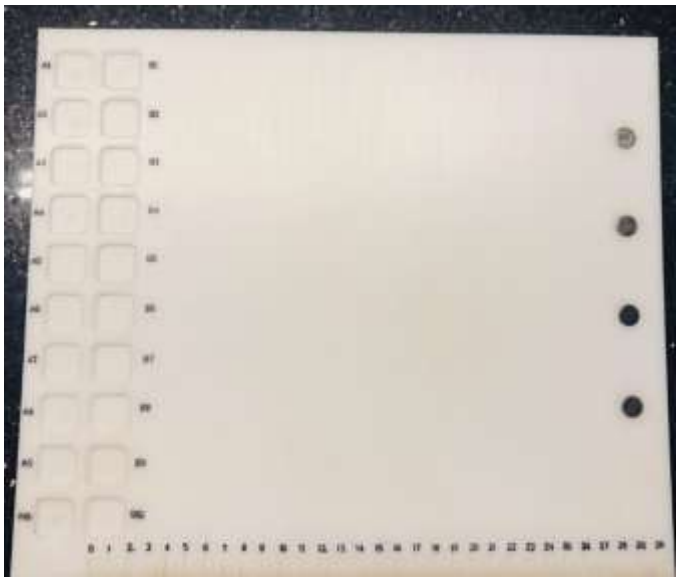

**Figure 1: PATHOGROSS: Modified Histopathological Grossing Board with Integrated Features**

### Material Selection, Fabrication, and Validation

Medical-grade Delrin (polyoxymethylene, SC698 NC010) was used as a board, and this type was chosen based on its mechanical strength, chemical resistance (formalin, ethanol, xylene), dimensional stability, and biocompatibility. The production processes were CNC face milling, contouring, cassettes slot pocket milling, magnet recess machining, laser

engraving, drilling and surface finishing. Dimensional accuracy (target tolerance of ±0.05 mm) was checked with digital vernier callipers.
Sterilization compatibility was tested using repeated autoclave cycles (121 C, 15 psi) and alcohol-based disinfectants and formalin. The pre- and post-cycle measurements were recorded to ascertain the dimensional stability and surface integrity.

**Crossover Workflow Procedure**
To standardize performance on both boards, participants were given a brief orientation. During the evaluation phase, both boards were assigned the same grossing tasks to all the participants under standard laboratory conditions. The sessions were balanced in terms of type and complexity of task (e.g. specimen measurement, sectioning, cassettes allocation and working with instruments). The order of the use of the board was alternated among the participants to reduce the impact of sequence. A fresh specimen was used in each of the sessions; none was re-grossed.
The workflow included specimen measurement using the inbuilt scale (Figure 2), organized placement of tissue sections in labelled cassette slots (Figure 3), and instrument handling using the magnetic docking system (Figure 4).

**Figure 2: Measurement of Surgical Specimen Using Inbuilt Laser-Engraved Scale on PATHOGROSS Board**

**Figure 3: Cassette slot utilization on PATHOGROSS board**

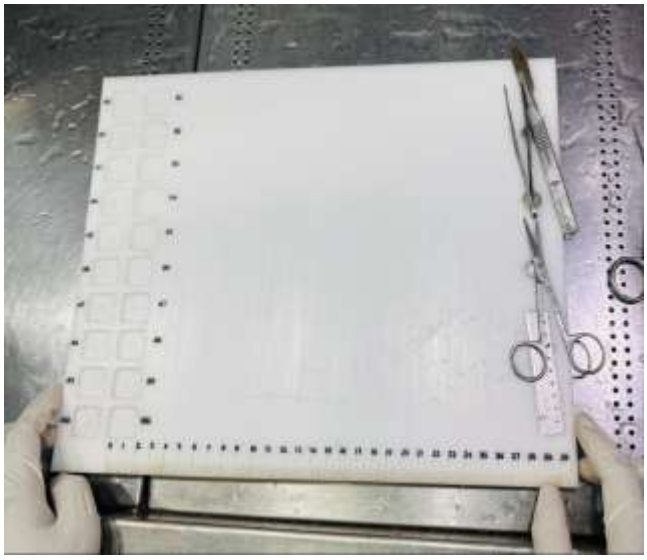

**Figure 4: Magnetic instrument docking on PATHOGROSS board**

**Scoring System**

Qualitative parameters were assessed using a 5-point Likert scale ranging from very poor (1) to excellent (5). Total scores were categorized into low (0–15), moderate (15–20), and high (20–25). Turnaround time was recorded as a continuous variable [13].

**Data Collection and Outcome Measures**

The structured assessment form was used to record data at the end of each session. The primary results were the decrease in turnaround time and the increase in workflow efficiency. The turnaround time was calculated as the number of minutes per specimen, and the workflow efficiency was evaluated on the Likert scale. Measurement accuracy, organization of the specimen, operator satisfaction and safety of handling the instrument were considered as secondary outcomes and evaluated by means of structured scoring and questionnaire-based evaluation.

**Statistical Analysis**

IBM SPSS 26.0 was used to perform statistical analysis. Statistics were in the form of mean and standard deviation. The Shapiro-Wilk test was used to test normality, and the paired t-test was used to compare. Statistically significant was a p-value of <0.05.

**Ethical Considerations**

Ethical approval was obtained prior to study initiation. Written informed consent was obtained from all participants. The study adhered to the Declaration of Helsinki and ICMR guidelines. Data confidentiality was maintained throughout.

**RESULTS**

A total of 60 specimens were included in the study and were equally grossed using the conventional grossing board and the PATHOGROSS modified grossing board by postgraduate trainees in pathology.

**Table 1: Grade distribution between conventional and PATHOGROSS methods**

| Grade Category | Conventional, n (%) | PATHOGROSS, n (%) |
|---|---|---|
| Grade I (Low) | 52 (86.7) | 0 (0.0) |
| Grade II (Moderate) | 8 (13.3) | 0 (0.0) |
| Grade III (High) | 0 (0.0) | 60 (100.0) |

Table 1 shows the grade distribution between the two methods. In the traditional group, the most common specimens were Grade I (low) [52 (86.7%), then Grade II (moderate) [8 (13.3%)], and no specimen of Grade III. In contrast, specimens in the PATHOGROSS group were all classified as Grade III (high) [60 (100%)], and no specimen was classified as Grade I or II, which indicates an excellent increase in the performance of grading.

**Table 2: Comparison of workflow parameters between conventional and PATHOGROSS methods**

| Parameter | Conventional (Mean ± SD) | PATHOGROSS (Mean ± SD) | *p*-value |
|---|---|---|---|
| Measurement accuracy | 2.50 ± 0.50 | 4.50 ± 0.50 | <0.001* |
| Cassette handling | 2.00 ± 0.00 | 4.50 ± 0.50 | <0.001* |
| Instrument handling | 1.00 ± 0.00 | 5.00 ± 0.00 | <0.001* |
| Workflow efficiency | 2.97 ± 0.90 | 4.43 ± 0.50 | <0.001* |
| Turnaround time (minutes) | 20.42 ± 9.27 | 9.55 ± 3.89 | <0.001* |

*Statistically significant at 5% level of significance

Table 2 summarizes the descriptive statistics of workflow parameters for both methods. PATHOGROSS System demonstrates great improvement in mean scores of all qualitative parameters as compared to the conventional method. Measurement accuracy improved from 2.50 ± 0.50 in the conventional method to 4.50 ± 0.50 with PATHOGROSS ($p < 0.001$). Cassette handling improved from 2.00 ± 0.00 to 4.50 ± 0.50 ($p < 0.001$), while instrument handling increased from 1.00 ± 0.00 to 5.00 ± 0.00 ($p < 0.001$). Workflow efficiency showed a significant improvement from 2.97 ± 0.90 to 4.43 ± 0.50 ($p < 0.001$). The mean turnaround time was significantly reduced from 20.42 ± 9.27 minutes in the conventional method to 9.55 ± 3.89 minutes in the PATHOGROSS group ($p < 0.001$).

Figure 1 illustrates the mean turnaround time for the two grossing methods. The conventional grossing board shows a higher mean turnaround t ime of 20.42 ± 9.27 minutes, whereas the PATHOGROSS board demonstrates a reduced turnaround time of 9.55 ± 3.89 minutes. The difference between the two methods is statistically highly significant ($p < 0.001$).

**Figure 1 - Difference In TAT Between Two Fixation Methods**

## DISCUSSION

The current study has shown that the PATHOGROSS modified grossing board significantly improves the workflow of the histopathological practice compared to the traditional grossing board. The most significant observation was the significant decrease in turnaround time (TAG), which fell to 9.55 ± 3.89 minutes ($p < 0.001$) compared to 20.42 ± 9.27 minutes, a more than 50 % reduction. This observation shows that there is a significant enhancement in the operational efficiency and points to the influence of integrated workstation design on the performance of the laboratory.

In addition to turnaround time, all of the assessed workflow parameters were statistically significant in the case of the PATHOGROSS system. The presence of an inbuilt laser-engraved scale also significantly improved measurement accuracy as it doesn't require additional measuring tools and minimizes inter-observer variability. Previous research confirmed the significance of the accurate gross measurement in ensuring proper pathological staging and diagnosis (1,2). Measurement, into the working platform, handling steps, and contributes to accuracy and efficiency.

The presence of labelled cassette slots greatly enhanced the handling of the cassettes and the organization of the specimens. An organized, structured approach reduce cognitive load and minimize the risk of misplacement or labeling error, which have been identified as the causes of workflow inefficiency in histopathology laboratories (14,15). In contrast, the traditional grossing boards do not have such features of organization and therefore cause interruptions and more time for handling.

The handling of instruments demonstrated the greatest improvement in all parameters. A magnetic docking zone was allowed to enable the secure and immediate access to the instruments, minimizing unnecessary movement and enhancing the safety of the operator. Ergonomic research indicated that an ergonomic placement of instruments greatly enhances the efficiency of the procedure and decreases fatigue (16). Lack of these features in traditional boards requires frequent repositioning, which disrupts workflow.

The PATHOGROSS resulted in a higher workflow efficiency, which was the cumulative effect of the enhanced measurement, organization, and handling of instruments. These results can be correlated with the principles of lean workflow design, when the integration of several steps into one system minimizes non-value-added processes and enhances productivity (17).

A strength of this study is that it is a within-subject crossover, with each operator serving as its own control. This design reduces the inter-operator variability and enables more reliable comparisons between the two methods. The consistency of the improvement observed across all parameters with highly significant statistical results supports the strength of the results.

Practically, the use of PATHOGROSS has significant limitations on histopathology laboratories, particularly in high volume where efficiency and turnaround time are crucial. Such integrated systems can help in achieving quicker reporting and better patient care by decreasing procedural delays and enhancing the organization of workflow.

However, it has its limitations, which must be acknowledged. The study was also conducted in a single center and with a limited number of operators, which could potentially impact the level of generalizability. In evaluation based on a Likert scale, there is a degree of subjectivity, although standardized scoring was employed. In addition, the study has not been evaluated based on long-term durability, cost-effectiveness or impact on diagnostic accuracy, which also needs to be examined. Future studies, including multicentric validation and larger sample sizes, would confirm these findings and explore broader applications.

## CONCLUSION

The current research has shown that the PATHOGROSS modified grossing board is much more efficient and effective in terms of workflow and efficiency in histopathological grossing compared to the conventional grossing board. The inbuilt measurement scale, labelled cassette organization system, and magnetic instrument docking are all integrated design features that help enhance the accuracy of measurements, handling of specimens, and the convenience of the operation of the operator.

The main result of this study is the significant reduction in turnaround time, as well as the significant enhancement of workflow efficiency and overall performance scores. The within-subject crossover design also supports these results by reducing inter-operator variability and gives a valid comparison of the two methods.

In general, the PATHOGROSS system is an effective and practical innovation in the histopathology workflow, and it can potentially increase the productivity of the laboratory and decrease delays in the procedures. Its application can be especially useful in high-volume pathology centers where high efficiency and accuracy are essential.

Further research involving larger sample sizes, multicentric validation, and cost-effectiveness analysis is needed to facilitate its use and assess its effect on diagnostic outcomes.

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