Original Article

# Quality Assurance in Histopathology Laboratory: A Comparative Study of Tissue Processing Techniques

**Pragnya Prabhu Patil[1], Prabhu Gouda[2], Narayan Dutt S J[3]**

[1]Fellow in Tumor Pathology, Department of Pathology, HCG hospital, Bangalore, Karnataka, India. [2]Assistant Professor, Department of Pathology, Andaman Nicobar Islands Institute of Medical Sciences (ANIIMS), Sri Vijaya Puram, Andaman & Nicobar Islands, India. [3]Senior Resident, Department of Pathology, Andaman Nicobar Islands Institute of Medical Sciences (ANIIMS), Sri Vijaya Puram, Andaman & Nicobar Islands, India

## Abstract

**Background:** Quality assurance in histopathology laboratories is essential for maintaining diagnostic accuracy, reproducibility, and timely reporting. Tissue processing is a critical pre-analytical step that directly influences tissue morphology and staining quality. Rapid tissue processing techniques have been introduced to reduce turnaround time while maintaining acceptable histological quality. The objective is to compare conventional and rapid tissue processing techniques with respect to tissue morphology, staining quality, diagnostic adequacy, processing artifacts, and turnaround time as part of quality assurance in a histopathology laboratory. **Material and Methods:** A prospective comparative observational study was conducted on 200 formalin-fixed tissue specimens. Each specimen was processed using conventional and rapid tissue processing techniques. Histological sections were evaluated for nuclear detail, cytoplasmic staining, tissue architecture preservation, sectioning quality, staining uniformity, processing artifacts, diagnostic adequacy, and overall quality score. Processing time and reporting turnaround time were also compared. Statistical analysis was performed using SPSS version 25.0, with a p-value <0.05 considered statistically significant. **Results:** Conventional tissue processing demonstrated slightly superior nuclear and cytoplasmic preservation and higher overall quality scores. However, rapid tissue processing achieved 97% diagnostic adequacy, with comparable tissue architecture preservation and minimal processing artifacts. The rapid technique significantly reduced mean tissue processing time (5.2 ± 0.8 hours) compared with conventional processing (14.6 ± 1.2 hours) and markedly shortened reporting turnaround time (15.8 ± 1.9 hours vs. 26.4 ± 2.5 hours, p<0.001). Most histological quality parameters showed no statistically significant differences between the two techniques. **Conclusion:** Rapid tissue processing yields tissue of histological quality and is adequate for diagnosis with a much shorter turnaround time in the laboratory. The use of proven rapid tissue processing methods in a quality assurance scheme can enhance the efficiency of the laboratory without compromising diagnostic quality.

**Keywords:** Used are Quality assurance, histopathology, tissue processing, rapid tissue processing, laboratory quality management, diagnostic adequacy and turnaround time.

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## Introduction

Histopathology is a corner stone of modern-day diagnostic medicine and is the only means of definitive diagnosis for the majority of inflammatory, infectious, benign, premalignant and malignant lesions. Histopathological diagnosis is dependent on the technical skill of the pathologist, as well as the quality of tissue processing carried out in the lab. The correct fixation, processing, embedding, sectioning and staining are essential to be able to interpret the tissue morphology and architecture in the microscope. Therefore, quality assurance (QA) has turned into an important part of histopathology laboratory practice to provide consistency, reliability and diagnostic excellence.[1-3]

The first and most important pre analytical step in histopathology is tissue processing. It entails dehydration, clearing, paraffin infiltration, embedding, and all these need to be carefully standardized to ensure quality tissue sections. Poor infiltration and shrinkage of the tissue, sectioning problems, staining artifacts and distortions of cellular morphology may be caused by inadequate tissue processing that may impact on diagnostic accuracy. As a result, optimization and continuous evaluation of tissue processing methods are crucial to achieve high standards in the laboratory.[2-4]

Quality assurance in histopathology involves a systematic monitoring and evaluation of all laboratory procedures to ensure that every specimen is processed in a standard manner. The internal quality control system, following standard operating procedures (SOPs), equipment maintenance, reagent quality control, and regular training for staff all help to reduce technical failures and to enhance reproducibility. The implementation of

**Address for correspondence:** Dr. Narayan Dutt SJ, Senior Resident, Department of Pathology, Andaman Nicobar Islands Institute of Medical Sciences (ANIIMS), Sri Vijaya Puram, Andaman & Nicobar Islands, India. E-mail: narayandutt.gokulam@gmail.com

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effective QA practices can not only improve diagnostic accuracy, but also minimize repeat processing, turnaround time, and laboratory expenses.[1,3,5]

With recent advances in histotechnology there are alternative methods and quick methods of processing tissues that not only decrease the processing time but also are designed to maintain a tissue morphology similar to the traditional overnight processing. These are newer techniques that help to enhance the efficiency of the laboratory and process in general, especially in high volume diagnostic centers. Nevertheless, there are potential issues of negative effect on nuclear detail, cytoplasmic staining, tissue architecture, sectioning quality and diagnostic adequacy. Hence, a comparison of various tissue processing methods is required prior to their routine use in diagnostic laboratories.[4-6]

Standardized tissue processing procedures, as well as consistent quality control have been shown to improve the quality of specimens, minimize technical artifacts and increase overall diagnostic accuracy. Increasingly, modern histopathology laboratories are placing a focus on quality assurance programs that monitor every step from the receipt of the specimen to the ultimate report, ensuring patient safety and adhering to international standards for laboratories.

Considering the increasing attention on quality management in the laboratory, the present study was conducted to compare the various tissue processing methods for their tissue morphology, staining quality, sectioning properties, artifacts in the processing, diagnostic suitability and time required for the processing. The study also aims to assess the role of quality assurance measures in improving the overall performance and reliability of histopathology laboratory services.

## Materials and Methods

**Study Design:** This was a prospective comparative observational study conducted to evaluate the quality of tissue sections processed using two different histopathological tissue processing techniques as part of the quality assurance program in the histopathology laboratory.

**Study Setting:** The study was conducted in the Department of Pathology of a tertiary care teaching hospital equipped with routine histopathology laboratory facilities.

**Study Duration:** The study was carried out over a period of 12 months after obtaining approval from the Institutional Ethics Committee.

**Sample Size:** A total of 200 formalin-fixed tissue specimens were included in the study.

**Study Population:** Histopathological specimens received in the pathology laboratory for routine diagnostic evaluation were enrolled consecutively during the study period.

**Inclusion Criteria**

- Formalin-fixed surgical biopsy and excision specimens.
- Adequately fixed tissue specimens received in 10% neutral buffered formalin.
- Specimens suitable for routine paraffin processing.
- Tissue blocks providing adequate material for comparative processing.

**Exclusion Criteria**

- Autolyzed or poorly fixed specimens.
- Specimens with extensive necrosis or severe crush artifacts.
- Decalcified bone specimens.
- Inadequate biopsy material.
- Previously processed or damaged tissue blocks.

**Study Procedure:** Each tissue specimen was divided into two comparable portions whenever feasible.

- **Group A (Conventional Tissue Processing):** One portion was processed using the routine overnight tissue processing protocol involving graded alcohol dehydration, xylene clearing, paraffin infiltration, embedding, microtomy, and routine Haematoxylin and Eosin (H&E) staining.
- **Group B (Alternative/Rapid Tissue Processing):** The second portion was processed using the rapid tissue processing protocol following the laboratory's standardized rapid processing schedule before embedding, sectioning, and H&E staining.

All tissue sections were cut at 4–5 μm thickness using a rotary microtome and stained using the same standardized H&E staining protocol to eliminate staining-related bias.

**Evaluation Parameters:** All slides were independently assessed by two experienced histopathologists who were blinded to the processing technique.

**The following parameters were evaluated:**

- Preservation of tissue architecture
- Nuclear detail
- Cytoplasmic staining quality
- Uniformity of staining
- Ease of microtomy
- Ribbon formation
- Presence of folds or chatter
- Tissue shrinkage
- Processing artifacts
- Overall diagnostic adequacy
- Turnaround time

**Each parameter was graded using a semi-quantitative scoring system:**

- 3 – Excellent
- 2 – Good
- 1 – Fair
- 0 – Poor

An overall quality assurance score was calculated for every specimen.

**Outcome Measures**

**Primary Outcome**

- Comparison of overall tissue quality between conventional and rapid tissue processing techniques.

**Secondary Outcomes**

- Nuclear and cytoplasmic preservation.
- Tissue architecture preservation.
- Sectioning quality.
- Frequency of processing artifacts.
- Diagnostic adequacy.
- Turnaround time.
- Overall laboratory quality assurance performance.

**Statistical Analysis:** Data were entered into Microsoft Excel and analyzed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation, while categorical

variables were presented as frequencies and percentages. Comparisons between the two tissue processing techniques were performed using the paired Student's t-test or Wilcoxon signed-rank test for continuous variables and the Chi-square test or Fisher's exact test for categorical variables. Interobserver agreement between the two histopathologists was assessed using Cohen's kappa coefficient. A p-value <0.05 was considered statistically significant.

## Results

A total of 200 formalin-fixed tissue specimens were included in the study. Each specimen was processed using both the Conventional Tissue Processing Technique and the Rapid Tissue Processing Technique. The quality of tissue sections was compared based on preservation of morphology, staining characteristics, processing artifacts, diagnostic adequacy, and turnaround time.

**Table 1: Comparison of Tissue Morphology and Staining Quality (n = 200)**

| Parameter | Conventional Processing n (%) | Rapid Processing n (%) | p-value |
|---|---|---|---|
| Excellent nuclear detail | 194 (97.0) | 186 (93.0) | 0.072 |
| Excellent cytoplasmic staining | 192 (96.0) | 184 (92.0) | 0.085 |
| Well-preserved tissue architecture | 196 (98.0) | 190 (95.0) | 0.119 |
| Uniform staining quality | 193 (96.5) | 187 (93.5) | 0.164 |

Conventional tissue processing showed marginally better nuclear detail, cytoplasmic staining, tissue architecture preservation, and staining uniformity than the rapid processing technique. However, the differences were not statistically significant (p>0.05), indicating that both techniques produced comparable histomorphological quality suitable for routine diagnosis.

**Table 2: Comparison of Sectioning Quality and Processing Artifacts**

| Parameter | Conventional Processing n (%) | Rapid Processing n (%) | p-value |
|---|---|---|---|
| Easy ribbon formation | 195 (97.5) | 188 (94.0) | 0.098 |
| Smooth section cutting | 193 (96.5) | 186 (93.0) | 0.112 |
| Minimal tissue shrinkage | 196 (98.0) | 191 (95.5) | 0.176 |
| Minimal processing artifacts | 194 (97.0) | 189 (94.5) | 0.205 |
| Adequate section thickness | 198 (99.0) | 195 (97.5) | 0.408 |

Both processing techniques yielded high-quality tissue sections with excellent ribbon formation and minimal artifacts. Although conventional processing demonstrated slightly superior sectioning characteristics, rapid processing also produced diagnostically acceptable sections in the majority of specimens without statistically significant differences.

**Table 3: Comparison of Overall Diagnostic Adequacy and Quality Scores**

| Parameter | Conventional Processing | Rapid Processing | p-value |
|---|---|---|---|
| Overall quality score (Mean ± SD) | 2.95 ± 0.16 | 2.84 ± 0.27 | 0.001 |
| Diagnostic adequacy n (%) | 198 (99.0) | 194 (97.0) | 0.248 |
| Histopathologist satisfaction score (Mean ± SD) | 2.94 ± 0.18 | 2.83 ± 0.26 | 0.003 |

Conventional processing achieved significantly higher overall quality and observer satisfaction scores (p<0.01). However, diagnostic adequacy remained very high in both groups, with 97% of rapidly processed specimens being considered suitable for definitive histopathological diagnosis.

**Table 4: Comparison of Turnaround Time**

| Parameter | Conventional Processing | Rapid Processing | p-value |
|---|---|---|---|
| Mean tissue processing time (hours) | 14.6 ± 1.2 | 5.2 ± 0.8 | <0.001 |
| Mean reporting turnaround time (hours) | 26.4 ± 2.5 | 15.8 ± 1.9 | <0.001 |

Rapid tissue processing significantly reduced both tissue processing time and overall reporting turnaround time compared with the conventional technique (p<0.001). Despite the marked reduction in processing time, the rapid method maintained excellent tissue morphology and high diagnostic adequacy, making it a practical option for high-volume laboratories and urgent biopsy specimens.

## Discussion

Quality assurance is essential in today's modern histopathology laboratories as it ensures that all aspects of the handling of the specimen, tissue processing, staining, and reporting is of a quality that is accurate and reproducible. One of the most important pre analytical processes is tissue processing as poor dehydration, clearing, paraffin infiltration or embedding may cause alteration of tissue morphology and have a negative impact on the diagnostic interpretation. In the present study, comparison between the two methods was made and it was shown that both processing methods produced high quality histological sections which were suitable for the routine diagnosis, with slightly higher overall quality scores for conventional tissue processing.

Conventional tissue processing showed slightly better nuclear detail, cytoplasmic staining, tissue architectural preservation, and good quality of sectioning than rapid processing in the present study. Most morphological parameters, however, showed no statistically significant differences between the above, suggesting that tissue sections of similar diagnostic quality can be produced by rapid tissue processing. These results are similar to those of Buesa who stated that changes in tissue processing techniques can significantly shorten the laboratory turnaround time with acceptable tissue morphology and staining properties needed for routine histopathological diagnosis.[8]

Conventional processing showed a significantly higher overall quality score and greater satisfaction among the histopathologists because of its proven ability of preserving fine histopathological details. However, high quality of staining was achieved by rapid tissue processing with a diagnostic adequacy of 97%, indicating that slight compromises in staining quality did not negatively impact pathological interpretation. The College of American Pathologists (CAP) Laboratory Accreditation Program also noted that the use of standardized tissue processing methods and ongoing quality monitoring are critical to ensuring consistent diagnostic performance regardless of the type of tissue processing used.[9]

One of the most significant finding of the present study was that rapid processing technique substantially reduced the turnaround time for the processing and reporting of tissues. The mean processing time was shortened from around 14.6 hours to 5.2 hours without adversely affecting diagnostic quality. This observation reinforces recommendations in ISO 15189:2022, which emphasize timely reporting, the use of a standardized approach for laboratory procedures, and continuous quality improvement as key elements in laboratory competence and patient care.

The World Health Organization (WHO) Laboratory Quality Management System also defines quality assurance as a process of continuous procedures, standard operating procedures, internal quality control, documentation, equipment maintenance and competence of staff members. The present results provide a clear indication that, within a proper quality assurance regime, a rapid processing of tissues can contribute to increasing the laboratory efficiency without compromising the diagnostic accuracy.

The present study also showed that there were minimal manufacturing artifacts in both groups, and cutting quality was very good. This has also been noted by Novis who states that the use of quality indicators like section quality, processing artifacts, turnaround time and diagnostic concordance play a major role in the improvement of laboratory quality and patient safety.[12]

Nakhleh said the ultimate goal of surgical pathology is to make the right diagnosis and not the process of making the diagnosis. The results of the present study show marked diagnostic adequacy with rapid processing which can confidently be used for routine histopathological reporting, provided appropriate quality assurance procedures are maintained.

Likewise, Zarbo pointed out that the ongoing monitoring of technical procedures, personnel competency, equipment validation and process optimization are essential to foster a culture of quality in anatomic pathology laboratories. Thus, the use of validated rapid tissue processing protocols can enhance the efficiency of the work flow without reducing the diagnostic quality.[14]

The present study's results also support the findings of Pantanowitz et al., who stated that it is important to validate laboratory procedures before they are used in the clinical setting to ensure consistency and diagnostic accuracy. When the techniques of rapid tissue processing are properly validated, the laboratory can use faster processing times without compromising compliance to international quality standards, or quality control requirements.

In general, the present study shows that rapid tissue processing is a useful method for enhancing the efficiency of the laboratory, which is most important in reducing turnaround time and in preserving tissue morphology and diagnostic quality equivalent to conventional processing. Rapid tissue processing can be used as an alternative option to routine histopathology with full quality assurance controls in high volume diagnostic laboratories, emergency specimens and in combination with a comprehensive quality assurance program.

## Conclusion

Quality assurance has a crucial role in the histopathological diagnosis to be accurate and reliable. Rapid tissue processing performed well with the same degree of staining quality as conventional tissue processing, with tissue architecture well preserved, few processing artefacts and good overall diagnostic quality. This significant time savings in processing and reporting are important for emergency biopsies and high-volume laboratories. Standardized quality assurance procedures combined with proven rapid tissue processing methods can improve laboratory efficiency and not affect the overall diagnostic accuracy and improve overall patient care.

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## Conflicts of interest

There are no conflicts of interest.

## References

1. Suvarna SK, Layton C, Bancroft JD, editors. Bancroft's Theory and Practice of Histological Techniques. 9th ed. Philadelphia: Elsevier; 2024.
2. Carson FL, Hladik C. Histotechnology: A Self-Instructional Text. 5th ed. Chicago: American Society for Clinical Pathology Press; 2021.
3. Kumar GL, Kiernan JA. Education Guide: Special Stains and H&E. 3rd ed. Agilent Technologies; 2018.
4. Kiernan JA. Histological and Histochemical Methods: Theory and Practice. 5th ed. Banbury: Scion Publishing Ltd; 2015.
5. Feldman AT, Wolfe D. Tissue processing and hematoxylin and eosin staining. Methods Mol Biol. 2014;1180:31-43. doi:10.1007/978-1-4939-1050-2_3.
6. Fischer AH, Jacobson KA, Rose J, Zeller R. Hematoxylin and eosin

staining of tissue and cell sections. Cold Spring Harb Protoc. 2008;2008(5):pdb.prot4986. doi:10.1101/pdb.prot4986.
7. Titford M. Progress in the development of microscopical techniques for diagnostic pathology. J Histotechnol. 2009;32(1):9-19. doi:10.1179/his.2009.32.1.9.
8. Buesa RJ. Histology without xylene. Ann Diagn Pathol. 2008;12(6):387-396. doi:10.1016/j.anndiagpath.2008.07.003.
9. College of American Pathologists. Laboratory Accreditation Program: Anatomic Pathology Checklist. Northfield (IL): College of American Pathologists; 2023.
10. International Organization for Standardization. ISO 15189:2022 Medical laboratories—Requirements for quality and competence. Geneva: ISO; 2022.
11. World Health Organization. Laboratory Quality Management System: Handbook. Geneva: World Health Organization; 2011.
12. Novis DA. Quality indicators in surgical pathology and laboratory quality improvement. Arch Pathol Lab Med. 2010;134(8):1093-1101.
13. Nakhleh RE. What is quality in surgical pathology? J Clin Pathol. 2006;59(7):669-672. doi:10.1136/jcp.2005.033431.
14. Zarbo RJ. Creating and sustaining a culture of quality in anatomic pathology. Arch Pathol Lab Med. 2006;130(5):630-640.
15. Pantanowitz L, Sinard JH, Henricks WH, Fatheree LA, Carter AB, Contis L, et al. Validating whole slide imaging for diagnostic purposes in pathology: Guideline from the College of American Pathologists. Arch Pathol Lab Med. 2013;137(12):1710-1722. doi:10.5858/arpa.2013-0093-CP.