



**Mini Review**

**Innovations in Oral Pathology Laboratory - A Mini Review**

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**Abstract**

Over the past two decades, a multitude of technological advancements have been integrated into histopathology laboratories, offering tools to enhance standardization and ensure occupational safety. Digital tracking plays a central role in guiding the entire process, from labeling cassettes and slides to the final stages of generating whole slide images, and storage of tissue blocks and tissue sections.

Versatile equipment has effectively replaced time-consuming manual tasks, which were susceptible to errors and material loss. Currently, collaborative robots are assuming responsibilities once exclusively carried out by humans. The emergence of these novel technologies is anticipated to help in improving oral pathology laboratory practices.

**Keywords:** innovations, automation, robotics, oral pathology, laboratory,

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## INTRODUCTION

Oral pathologists are specialized dentists dealing with histopathological and immuno-histochemical diagnosis of biopsy specimens, fine needle aspiration cyto-logy, exfoliative cytology, and analysis of biological samples referred for hematology, biochemistry, and microbiology. They correlate histopathological features with clinical and radiological findings, and either directly treat or indirectly guide the treatment of patients.

Innovations in oral pathology labs have been driven by advances in technology, diagnostics, and research. These innovations have improved the accuracy, efficiency, and effectiveness of diagnosing oral diseases.

## REVIEW:

Here are some notable innovations in oral pathology labs.

1. **Digital Pathology:** Digital pathology involves scanning glass slides to create high-resolution digital images. This technology allows pathologists to view and analyze slides remotely, collaborate with experts worldwide, and store vast amounts of data. It can improve diagnostic accuracy and streamline the workflow.
2. **Artificial Intelligence (AI):** AI and machine learning algorithms can analyze digital pathology images to identify patterns and abnormalities. They can assist pathologists in making more accurate and consistent diagnoses. AI tools can also predict disease progression and treatment outcomes.
3. **Telepathology:** Telepathology enables pathologists to consult with colleagues or access expertise from a distance. This is particularly useful in remote areas or for obtaining second opinions on complex cases.
4. **Biomarker Analysis:** Advances in genomics and proteomics have led to the discovery of specific biomarkers associated with oral diseases. Lab techniques for biomarker analysis can help identify disease risk, prognosis, and treatment response.
5. **Liquid Biopsies:** Liquid biopsies involve the analysis of saliva and blood for oral cancer markers. This non-invasive approach is valuable for early detection and monitoring of oral cancers.
6. **3D Printing:** 3D printing technology is used to create anatomical models, prostheses, and surgical guides. In oral pathology, this can help plan complex surgeries and improve the precision of interventions.
7. **Next-Generation Sequencing (NGS):** NGS technology has revolutionized genetic testing, enabling comprehensive analysis of the DNA, RNA, and epigenetic changes in oral diseases. This can lead to more personalized treatment options.
8. **Big Data and Data Analytics:** Large-scale data collection and analysis allow researchers to identify trends, risk factors, and treatment outcomes more effectively. This can lead to evidence-based clinical decisions.
9. **Immunohistochemistry and Molecular Pathology:** These techniques have become increasingly important in the diagnosis and classification of oral diseases, especially in distinguishing between different types of tumors.
10. **Automation and Robotics:** Automation in pathology labs can increase efficiency and reduce the risk of human error in sample processing, staining, and slide preparation.
11. **Tissue Engineering and Regenerative Medicine:** Innovations in tissue engineering are being used to create bioengineered tissues for reconstructive purposes in oral surgery. This technology has the potential to revolutionize the treatment of oral pathologies and injuries.
12. **Personalized Medicine:** Tailoring treatment plans to an individual's genetic and molecular profile is becoming more common. This allows for more effective and targeted therapies in the field of oral pathology.

Automation and robotics are increasingly being integrated into oral pathology labs to improve efficiency, accuracy, and consistency in various laboratory processes. Here are some key areas in which automation and robotics are making an impact in oral pathology labs:

1. **Specimen Processing:** Automation can handle tasks like specimen labeling, sorting, and tracking, reducing the risk of errors and ensuring samples are properly managed.
2. **Slide Preparation:** Robotic systems can automate slide preparation, including cutting, staining, and cover-slipping. This not only speeds up the process but also ensures consistent staining and sample quality.
3. **Digital Imaging:** Automated robotic microscopes and slide scanners can capture high-resolution digital images of pathology slides. This technology facilitates remote access for pathologists and enables computer-assisted analysis.
4. **Sample Archiving:** Automated storage and retrieval systems ensure that specimens are preserved, organized, and easily accessible for future reference or research.
5. **Data Entry and Record-Keeping:** Robotics can assist in data entry and maintaining accurate records, reducing the chances of manual transcription errors.
6. **Barcode Scanning:** Automated systems can scan and read barcodes on specimens and slides, streamlining the tracking and identification of samples.
7. **Quality Control:** Robots can perform quality control checks on prepared slides, helping to identify any irregularities or issues.
8. **Material Handling:** Automation can transport materials and samples within the lab, optimizing workflow and reducing the need for manual handling.
9. **Liquid Handling and Dispensing:** Robotic systems are used for accurate and consistent dispensing of reagents and fluids for various lab processes.
10. **Pathologist Assistance:** While not a replacement for human pathologists, AI-driven robotics can assist pathologists in image analysis and pattern recognition, aiding in diagnosis and research.
11. **Inventory Management:** Automated systems can monitor inventory levels, reorder supplies as needed, and ensure that the lab is well-stocked.
12. **Sample Tracking and Traceability:** Automation can help ensure full traceability of samples, from collection to analysis, reducing the chances of mislabeling or mix-ups.

The integration of automation and robotics in oral pathology labs offers several advantages, including increased productivity, reduced human error, faster turnaround times, and improved data management. It also allows pathologists to focus more on the critical aspects of diagnosis and research. However, it's essential to maintain a balance between automation and the expertise of oral pathologists to ensure accurate and reliable results.

## CONCLUSION:

These innovations are improving the accuracy and efficiency of oral pathology diagnostics and are likely to continue evolving with advancements in technology and research. They contribute to better patient care and outcomes in the field of oral health.

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## Conflicts of interest

There are no conflicts of interest

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