Quantifying the Value of AI-Powered Digital Workflows in Real-World Diagnostic Laboratories

Insights from a Quest Diagnostics Feasibility Study Conducted with Proscia and Ibex Medical Analytics

Overview of Results:

- Deeply integrated AI-powered workflows drive lab efficiency, allowing pathologists to sign out 2.9 cases per hour instead of 1.2.
- Digital pathology is easy to use and learn, and pathologists are eager to adopt Proscia's Concentriq® with Ibex Galen™ Prostate.
- Galen Prostate is highly accurate in detecting cancer and other pathologies, and in alignment with the accuracy of the pathologists' diagnoses.

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Introduction

According to the International Agency for Research on Cancer, approximately 1 in 5 people will develop cancer during their lifetime, and for 1 in 8 men and 1 in 11 women, it will be fatal.[1] Factors such as aging populations and socioeconomic risk factors are driving up cancer rates at a shockingly high pace, with the global cancer burden expected to rise by 47% between 2020 and 2040.[2]

The question is, how will diagnostic pathology labs evolve to keep pace?

Commercial labs—both large and small—already face high case volumes. They need new ways to scale to meet future demands, grow profitably, and ensure fast turnaround times in the face of significant industry challenges, including:

- **The global shortage of pathologists.** According to a recent analysis of the 2021 College of American Pathologists Practice Leader Survey, just 65% of practices looking to hire pathologists could fill all open positions, marking a decline from 2017.[3] And in the UK, for example, only 3% of practices have enough staff to meet clinical demand.[4]
- **Growing pathologist burnout.** About 33% of pathologists report feeling burned out today—and for good reason.[5] Workforce shortages and rising biopsy volumes increased pathologists' workloads by 42% between 2007 and 2017—and those trends have only accelerated.[6]
- **Declining reimbursements.** Insurance companies are regularly cutting reimbursement rates for anatomic pathology services, resulting in less revenue, tighter margins, and greater pressure to process more volume in less time.

Quest Diagnostics®, the world's leading provider of diagnostic testing, information, and services, is not immune from these trends. Leadership recognized that to overcome these challenges, they needed to turn toward harnessing innovations such as digital pathology (DP) and AI-enabled diagnostic tools.

AI-Powered Digital Pathology Is Transforming Routine Diagnostic Practice

The increasing prevalence of chronic conditions and diseases like cancer has intensified industry interest in digital pathology solutions that can improve patient diagnostic imaging methods. Thanks to technological advances in the past decade and the many benefits of DP, adoption is accelerating. DP shifts the diagnostic process from microscope to whole slide image, unlocking insights previously unseen by the human eye to realize the promise of precision medicine. It also drives powerful efficiency gains that are helping laboratories to overcome a range of systemic challenges.

Diagnostic artificial intelligence (AI) tools can be embedded into DP workflows. Numerous studies have demonstrated AI's potential to improve diagnostic accuracy, save time, and support pathologists in their decision-making, for example, by performing sophisticated image analysis and computer-aided diagnosis.[7]

DP and AI technologies have enormous potential to impact the pathologists' experience and overall job satisfaction, while delivering economic and operational returns.

To meet growing demand, Quest collaborated with Proscia, an industry-leading enterprise digital pathology platform provider, and Ibex Medical Analytics (Ibex), a leading provider of AI-powered diagnostics for pathology, to run a feasibility study of their networked pathology solution in one of their labs. Quest wanted to translate the general findings of the study to understand how these technologies impact lab operations and their effects in a large diagnostic lab setting.

About the Study

Quest, Proscia, and Ibex opted to have the study focus on prostate tissue captured using core needle biopsies (PCNBs). Prostate cancer is the second most commonly occurring cancer in men, with more than 1.4 million new cases annually. PCNBs are routinely used by physicians to test patients for cancer and ensure accurate, timely diagnosis, which is instrumental in guiding treatment decisions and improving survival rates.

However, rising case volumes and complexity can lead to slower turnaround times for biopsies. Reviewing cases using traditional methods—where pathologists view 24 H&E (hematoxylin and eosin) slides per case, on average, using a microscope and manually recorded information—takes time. In addition, subjectivity in Gleason grading, the small size of certain tumors, the increased demand to report features beyond cancer, and the large number of tissue cores per case complicate case reviews. These realities made PCNBs an ideal area of focus to understand the impacts of DP and AI.

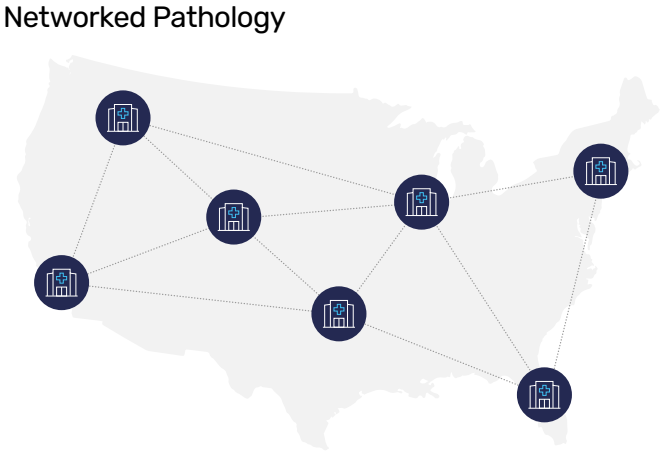
The joint solution* used in the study embeds Ibex's Galen Prostate, a clinical-grade, AI-powered solution that assists pathologists in improving the detection and grading of prostate cancer, within Concentriq® Dx, Proscia's digital pathology workflow solution. Concentriq Dx streamlines pathologists' review of tissue samples that have been scanned at high resolution to create digital slides, or whole slide images (WSIs), which pathologists can then view.

Study Goals

While Galen Prostate had demonstrated outstanding outcomes in prior rigorous clinical studies at institutes across the world,[8] the goal of this study was to evaluate its impact on pathologist reading time within a DP workflow and the AI's utility and impact in a large-scale pathology lab.

The study was designed to achieve 4 aims:

1. Assess any potential improvements in the routine diagnostic workflow enabled by Concentriq Dx and Galen Prostate
2. Determine the AI algorithm's accuracy in detecting the presence of adenocarcinoma by measuring the major discrepancy rate between pathologists' reads using Galen Prostate versus pathologists' reads without it, as well as measuring the Gleason grading
3. Assess the ease of adoption and use of these technologies for pathologists used to a traditional, microscope-based workflow for case sign-out
4. Understand how these technologies impact the overall experience for pathologists



Distributed workload management for a laboratory networked through digital workflows

* This study was performed on early versions of Concentriq Dx, to which results from Ibex's Galen™ Prostate were embedded. Concentriq Dx is now cleared for primary diagnosis in the European Union (EU), Switzerland and UK. Concentriq Dx is Health Canada licensed. Galen Prostate is for Research Use Only (RUO) in the United States and not cleared by the FDA. Galen Prostate is CE (IVDR) and approved for use in other countries. Results are specific to the institution where they were obtained and may not reflect results achievable at other institutions.

The Methodology

The study was designed as a retrospective observational study that included 180 randomized prostate cases from adult (21 or older) subjects (including 4,366 H&E stained slides from Prostate Core Needle Biopsies), with a partial crossover design that consisted of two arms:

- **Arm A** — Digital Read: An arm in which WSIs were read digitally using Concentriq Dx
- **Arm B** — Digital + AI Read: Cases were read digitally using Concentriq Dx including embedded results of Galen Prostate. Information provided by the AI was pre-filled into Concentriq Dx

Slides were digitized with a magnification of 40x using a Leica GT450 scanner in the Quest facility in Tampa, Florida. To be included in the study, each case had to have all of its H&E slides digitized and processed by the scanner to create high-resolution images, as illustrated in Figures 1 (DP without AI overlay) and 2 (DP with AI overlay). PCNB cases were excluded if slides were of inadequate technical quality, were from subjects under the age of 21, or were captured during an out-of-range time period.

Cases and associated WSIs were read in both arms of the study (Arm A and Arm B) by all three board-certified pathologists, all of whom had different levels of professional experience and backgrounds. None had previous experience with DP or AI in clinical practice.

Figure 1: Example of digitized slide of a PCNB tissue sample (WSI) for review in the Concentriq Dx DP workflow (no AI overlay).

Figure 2: Example of digitized slide of a PCNB tissue sample (WSI) in the Concentriq Dx DP workflow with Galen Prostate AI overlay highlighting the high cancer likelihood areas.

What Was Studied

By analyzing and comparing both data sets, the research team was able to measure the real impacts of the added AI with a focus on:

- **AI performance.** Accuracy of cancer detection / Gleason grading, and other clinically relevant lesions, such as perineural invasion (PNI)
- **Ease of use.** Software usability and learning curve for pathologists
- **Lab efficiency.** Overall lab and business efficiencies gained through the combined use of DP and AI

For each of the 180 cases, the study design* resulted in the capture of data in two workflows:

- Digital reads using the Concentriq Dx-only workflow, where pathologists examined the WSIs and determined a diagnosis of benign, undetermined, or cancer
- Digital reads assisted by Galen Prostate AI, which was embedded in the Concentriq Dx workflow

* For both workflows, pathologists reviewed H&E-stained slides only, without the possibility to review additional immuno-stained slides.

Altogether, the study generated 92,130 data points (see Table 1). Results were captured through User-Defined Fields (UDFs) directly in Concentriq Dx, as well as timestamps generated in Concentriq Dx for reading time analysis. In the AI arm, results of Galen Prostate were pre-filled into the UDFs according to Table 1. Additional pathologic findings, such as high grade PIN, atrophy and inflammation were presented as heatmap overlays. Pathologists had the possibility to change any UDF data during their review in both arms of the study. To capture data on pathologists' adoption and user experience, pathologists were asked to complete surveys after they completed their case readings.

Table 1: A summary of the data captured for each slide.

Data Collected per Slide	Method	Prefilled (AI Arm)
Cancer present on the slide	Yes, Undetermined or No	Yes
IHC required to review the slide	Yes or no	No
Length of core tissue	Numeric value	Yes
Length of tumor tissue	Numeric value	Yes
Tumor %age	Numeric value	Yes
Gleason Grade for Cancer	List of Gleason Grades along with Grade Group (eg "4+4 (Grade Group 4")	Yes
%age of Gleason Pattern 4	List of %ages in steps of 5%	No
PNI present on the slide	Yes or no	No

Significant Potential Impact on Laboratory Operations with AI-powered Digital Pathology

The study quantified the potential value-add of digital pathology workflows in large lab environments, as well as the value-add of embedding AI into these workflows. At a high level, the study showed that:

- Concentriq Dx was easy for pathologists to adopt, and the digital workflow streamlines work experiences
- Embedding Ibex's Galen Prostate vastly reduced case review time, increased pathologists' confidence in their diagnoses, eliminated manual work, and more

Digital Pathology — Easy to Get Started and Use

The pathologists found Concentriq Dx to be intuitive to learn and easy to use, rating it 3.33 out of 4.0 on intuitiveness in the post-study survey. Additionally, the reading pathologists, all with limited or no experience in diagnosing in digital workflows, reported no significant change in the confidence of their diagnosis when they reviewed cases using a high-resolution monitor rather than a microscope.

While the pathologists needed a little time to get used to image differences associated with scanning (such as paleness and the need for contrast settings) and the overall digital pathology user environment, they all found the Concentriq Dx software to be "very pathologist-friendly" and with "superior ergonomics compared to a microscope." All three pathologists found the digital pathology experience easy to grasp, allowing them to hit the ground running quickly. In particular, they noted in the surveys:

- The super-fast and smooth viewing experiences enabled by Concentriq Dx
- The automatic preloading of measurements and other DP & AI insights into the reporting forms was considered "the best"
- New, time-saving functions such as the "mega useful" digital ruler, tagging, and virtual slide tray
- Getting a sense of the possibilities that a digital workflow will provide: ability to quickly and easily access specific cases and slides for consultation calls, and networked workflows across sites
- The ability to quickly and easily access specific cases and slides for consultation calls
- The new possibilities that DP workflows create, such as working from home

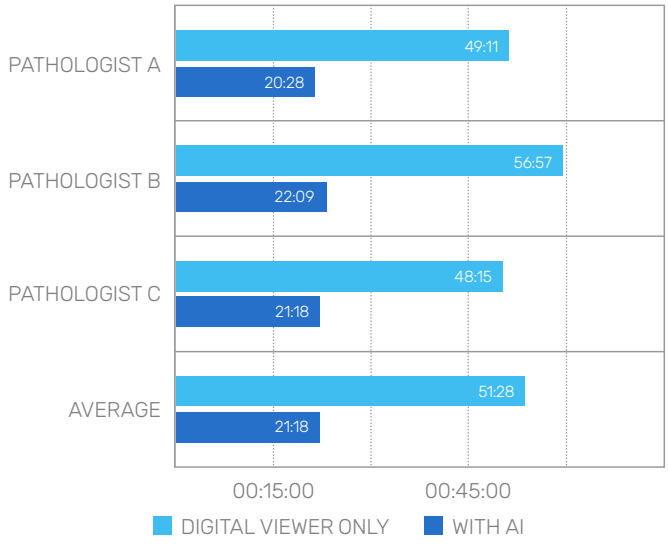
Learning Curve

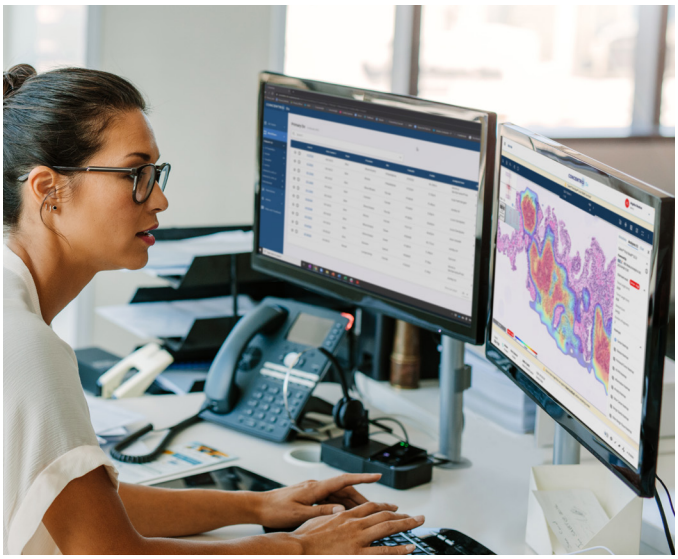
The three reading pathologists all indicated to have limited to no prior experience with reading cases on a digital system. Prior to starting the reading, pathologists received a 90-minute training session along with the possibility to use the system on a set of training cases, independent from the study slides.

The trend in reading time seen for the individual pathologists shows a small reduction in reading time based on how many cases have been read (see Figure 3 on next page). Feedback from the reading pathologists was that they did not experience a noticeable learning curve using Concentriq Dx, but that the variation in reading time for Concentriq Dx without AI was driven mainly by diagnosis and data entry. This provides evidence for the intuitiveness and ease of use of Concentriq Dx, and the ability for pathologists to efficiently use the system for diagnosis even with limited prior experience.

Furthermore, the intuitiveness of the AI-enabled digital workflow was evidenced when adding Galen Prostate results to the workflow (see Figure 3). For the reading times in the AI arm, the trend in reading time over time also shows limited influence by how many cases have been read in a similar workflow before by the pathologist. Overall, it is noticeable, however, that the reading times are more consistent, with a much smaller difference between cases. In discussing with the pathologists after reading had finished, they confirmed that the AI insights helped to harmonize the flow of reading, especially through prefilling of measurements such as core length and tumor length.

Figure 3: Average case reading times with and without AI in minutes





Highly Accurate AI

Cancer detection by Galen Prostate was highly accurate and in alignment with the accuracy of the pathologists' diagnoses. Pathologists supported by AI demonstrated high performance, as evidenced by the Negative Predictive Value (99.9%), Positive Predictive Value (99.1%), and very high accuracy for cancer detection with an AUC of 0.997 (95% CI:0.994-0.999). For Gleason grading, the pathologists using the Ibex Galen AI technology showed high levels of agreement (90%) with the adjudicator. AI Arm ICC=0.945 (95% CI [0.934, 0.955]).

Pathologist results without AI	Pathologist results with AI	Parts
Benign	Malignant	0
Malignant	Malignant	437
Undetermined	Malignant	12
Benign	Benign	1,354
Malignant	Benign	1*
Undetermined	Benign	164
Benign	Undetermined	68
Malignant	Undetermined	40
Undetermined	Undetermined	107

NPV = 99.9% Negative predictive value	**PPV = 99.1%** Positive predictive value

Table 2: Pathologists supported by AI demonstrate high performance in cancer detection with high NPV and PPV values. Thus, supports the viability of this solution for use in routine practice.

* Part determined as benign by the adjucator

The study demonstrated that Galen Prostate can accurately analyze slides and even helped pathologists find and report 5% more PNI-positive parts compared to the baseline DP workflow, as shown in Figure 4. This improvement indicates that AI resulted in fewer missed PNIs, reducing the number of patients with PNIs who are underdiagnosed and go without the appropriate treatment plan.

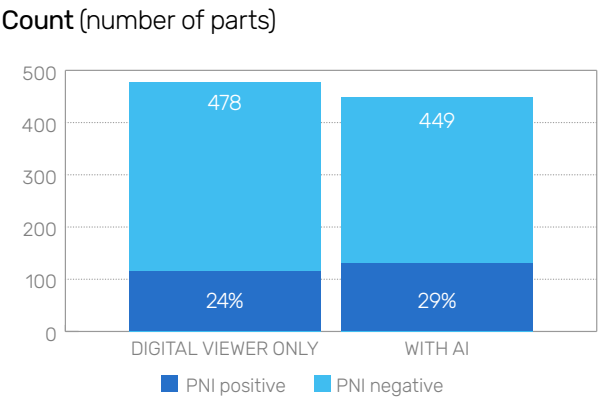


Figure 4: Number of detected PNIs increased by 5% in the AI-enabled arm of the study compared to the baseline read.

Deeply Integrated AI Drives Lab Efficiency

Upon completion of the reviewer study, the pathologists were surveyed in order to assess the potential of deeply integrated AI in their routine workflow. Several areas of laboratory efficiency and pathologist experience improvement with AI were identified. For instance, the pathologists mentioned:

- The impact on benign slide reviews within the scope of the study, as they used to *"always look at benign slides twice. The AI enables me to look only once."*
- Reduced time spent on measurements, with automated, AI-generated tumor length
- Time-saving functions such as the *"incredibly useful"* digital ruler, tagging, and virtual slide tray
- The accuracy of the AI-generated digital ruler measurements *("the trust is there")*, especially when combined with the freedom to change values if they disagree with the AI
- Better workflow planning and confidence through cancer classification and heatmap functionality
- The PNI indications, which they considered *"very useful"* and *"amazing"*

100% of Pathologists Reported They Are 'Much More Likely' to Adopt AI

Survey responses indicate that the three pathologists considered the combined DP and AI solution a "game changer" that "no doubt…is the preferred way to sign out cases." They "can't wait" to use this "beautiful product" in their daily work. This feedback suggests that deployment of these technologies at scale would be welcomed by pathologists, and that real-life experiences help to see how digital workflows may benefit them and their daily operations.

This positive feedback shows the importance of digital workflows in pathology laboratories for talent acquisition and retention. High-performing companies, regardless of industry, actively look for ways to enrich their employee experience in ways that lead to purposeful, productive, and meaningful work. For recent digital-native graduates, companies need to provide a work environment that uses new digital technologies to automate manual tasks, streamline collaboration, and empower them to do meaningful, impactful work. In times of pathologist shortages, providing the benefits of a digital, AI-empowered workflow can be an important element for a lab to be an attractive employer.

The Real Impact on Pathologist Workflows

The positive experiences pathologists had using Concentriq Dx and Galen Prostate were also influenced by important workflow improvements to simple case-by case tasks. A reduction in manual data entry, and auto-population of results into patient reports ultimately saves time and shows great potential to reduce transcription errors and associated costs.

AI-empowered workflows in this study made it easier for pathologists to manage workloads and make faster, more confident diagnoses, both of which are key ingredients to an improved work/life balance and overall job satisfaction.

Business Opportunities Enabled Through Digital Workflows

For pathologists who are being paid on a per-case basis, these efficiencies can translate into a higher earning potential, which is key to attracting more new talent to address the pathologist shortage. In this study, for example, AI allows pathologists working in such a model to sign out 2.9 instead of 1.2 cases per hour, potentially increasing their income significantly.

Automated AI-powered analysis prior to pathologist review through Galen Prostate offers the potential to optimize downstream workflow requests, such as requesting additional immunohistochemistry (IHC) tests for the case as well as the request for a secondary review for cases with malignancies. These optimizations potentially can improve turnaround time for the lab, and subsequently lead to better service levels, which increase the competitiveness of the laboratory. With the results of the AI, for example, slide findings may be provided in a summary report at the beginning of the sign-out work for the pathologists. This data would allow the pathologists to make their scheduling requests for additional IHC stains and secondary review in the morning, ensuring a turnaround on the same day rather than the next day. An automated pre-ordering policy could be developed based on the available data, further helping with harmonization of operations and predictability of workload.

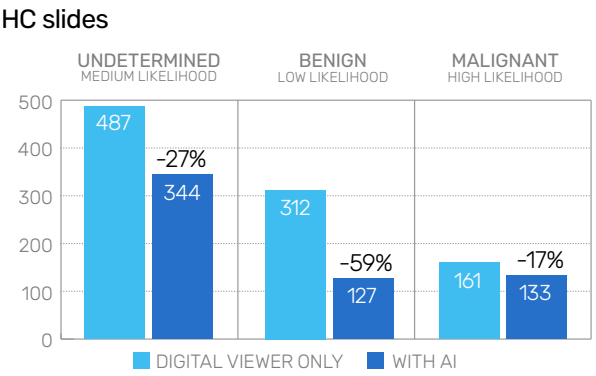


Figure 5: Ibex's Galen Prostate helped reduce requests for IHCs by an average of 37%.

Conclusion

To date, few clinical studies have focused on demonstrating the accuracy and impact of AI in digital pathology workflows—and none had been done in a large-scale diagnostic laboratory setting with preloaded AI results. This study shows the potential benefits for diagnostic labs—both large and small—so they can properly assess the value of these technologies and make the best decisions as they plan ahead for future investment.

The study clearly demonstrated that DP and AI from Proscia and Ibex offer significant potential return on investment focused on key value drivers for the business. The study also demonstrated that AI is highly accurate and easy to use when embedded into the digital pathology workflow. Pathologists have shown significant interest in adopting the technology for their daily workflows, as the efficiencies it can provide as an integrated solution can save time, reduce costs, boost margins, and enable pathologists to do more volume in less time—with less stress and greater work/life balance.

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About Quest Diagnostics

Quest Diagnostics empowers people to take action to improve health outcomes. Derived from the world's largest database of clinical lab results, our diagnostic insights reveal new avenues to identify and treat disease, inspire healthy behaviors, and improve healthcare management. Quest Diagnostics annually serves one in three adult Americans and half the physicians and hospitals in the United States, and our nearly 50,000 employees understand that, in the right hands and with the right context, our diagnostic insights can inspire actions that transform lives.

About Proscia

Proscia is a software company that is accelerating pathology's digital transformation to change the way we understand diseases like cancer. Its Concentriq digital pathology platform and powerful AI applications are advancing the 150-year-old standard of research and diagnosis towards a data-driven discipline, unlocking new insights that accelerate discovery, improve patient outcomes, and fulfill the promise of precision care. Leading diagnostic laboratories and 14 of the top 20 pharmaceutical companies rely on Proscia's software each day.

About Ibex Medical Analytics

Ibex is transforming cancer diagnostics with clinical grade AI-powered solutions for pathology. Empowering clinicians and supporting pathologists, Ibex is on a mission to provide accurate, timely and personalized cancer diagnosis for every patient. Ibex's Galen is the first and most widely deployed AI-powered platform in pathology. Pathologists worldwide use Galen as part of their everyday routine to improve the accuracy of cancer diagnosis, implement comprehensive quality control measures, reduce turnaround times, and boost productivity with more efficient workflows.

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