

# Evaluation of the influence of compression (megapixels) in the diagnosis of alveolar bone loss in digitized radiographs using digital cameras

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## Abstract

**Introduction:** This study aimed at evaluating the required digital camera resolution used for radiograph digitalization. **Material and Methods:** Periapical radiographs were selected from the undergraduate dental clinics at Ingá University (UNINGÁ) and digitalized with three different amateur digital cameras which were set at different megapixel resolutions. **Results:** Sony W110 digital camera showed similar acceptability results in all evaluated resolutions, which were VGA, 3, 5 and 7 megapixels (96.6%, 94.7%, 97.3% and 97.3% respectively). Fujifinepix 2800HD digital camera presented a 100% of acceptability when set at 7 megapixels resolution. Sony T110 digital camera showed acceptable results when set at 5 megapixels resolution or higher. **Conclusions:** The best results were obtained with Fujifinepix 2800HD digital camera when set at a 7 megapixels resolution. The three brands evaluated, when set at a 5 megapixels resolution or higher, showed adequate results for diagnosis.

**Keywords:** Digital radiograph. Resolution. Scanning.

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## Introduction

Fast technological development aids all professionals in planning, executing and completing their services. Countless documents are currently being digitized, databases are being created and, as a result, statistics arise in a simple click. The use of digital imaging has increased among dentists, however, due to the lack of proper knowledge, the results have been unsatisfactory, since distorted images are produced with little or no sharpness.<sup>1</sup>

There are several methods for digitizing a radiographic image, and the advent of computers has contributed to increase the use of digital imaging in Dentistry. Digitizing an image means converting it into numeric data and storing it into a computer hard drive. This is done through a process called sampling. Sampling means to divide the original image into small squares (samples) and assign to each one of them a number that represents the color of that part of the image. This allows the image to be represented by a set of numbers that can be stored in a computer. There are several options that can be used for digitalization, namely: scanners, digital cameras, digital radiographs, and video cameras.<sup>2</sup>

The current use of digital imaging is a result of scientific advancements that allow professionals to use what had been once unconceivable. Digital imaging has aided the diagnosis of malocclusions and the communication between professionals and patients. In addition, it has served as an excellent tool for prospectively and retrospectively evaluating the evolution and the outcomes of periodontal treatment. Moreover, it is also an excellent option for professionals who have a significant amount of records and want to digitize them, so that the documents that take a large amount of space can be converted into digital files and stored into medias such as CDS (compact disks) or USB drives.

The digitizing process with the use of scanners is slower and high-end equipment tends to be expensive. On the other hand, digital cameras can perform the same process in a faster way, yielding satisfactory results. The main advantages of the digital system is that it enables immediate display of the images, eliminates the cost of films and photo development, and allows simplified systematic management of images in the dental practice. Another advantage is the possibility of manipulating and editing the images, which significantly facilitates interpersonal communication and produces better results.<sup>3-9</sup>

According to Lemos et al<sup>10</sup> the photographic image has some disadvantages depending on the equipment chosen. Lens, flash light, batteries, proper lighting and focal point can affect the final quality of the image. However, little is known in the literature about how to properly use photographic equipment, and there are no standard guidelines for digitizing radiographs.<sup>10</sup>

Initially, it is necessary to clarify some terms so as to facilitate understanding throughout this article. Digitizing an image means to turn it into a computer file: physical and palpable material (slides, dental casts and radiographs) become virtual (displayed on a computer screen).

Various devices, including video cameras, digital cameras, scanners, digital radiograph machines, electronic microscopes, radars and ultrasound machines, can produce these digital images. Thus, it is important to differentiate "digital image" from "digital photograph".

Digital photograph is a type of digital image that is strictly obtained by the use of digital cameras. All digital files are essentially a series of binary digits, 0 and 1, which form tiny frames. Each frame is named pixel (the short form of "picture element", or the elements of an image) which is the basic unit that forms digital images.<sup>2</sup>

Image resolution is directly proportional to the amount of pixels. As previously described, the measurement unit of image resolution is the pixel, and the more pixels an image has, the greater its resolution will be. However, the main drawback is that images with high resolution produce large digital files, taking up a lot of computer memory space, which can hinder its performance, especially when using these images in multimedia presentations. Thus, the ideal is to obtain digital images as simply and fast as possible, with satisfactory quality and with the smallest size necessary for its purposes.

The resolution of an image is also commonly measured by DPI (dots per inch). In fact, every image is formed by PPI (pixels per inch) when it is digitally captured. Only when the image is printed it can be defined by DPI, because it ceases to be virtual and becomes physical. Therefore, it is correct to say that an image was printed in DPI, but if it is seen on a computer screen, it should be defined in PPI. This concept frequently causes confusion, even within the scientific community. Some journals erroneously require that scientific authors submit digital photographs with maximum resolution, others even specify values such as "minimum 8 megapixels resolution."

Unfortunately, this is a serious mistake, since the image resolution for printing is defined in DPI and not in megapixels. The Dental Press Journal of Orthodontics, for instance, requires that authors submit 300DPI images. These images can have 3, 5, 7, 10, 15 megapixels or more, but when printed on paper, their resolution must be of 300 dots per inch.<sup>11</sup>

Among the many technological innovations associated with new digital cameras, manufacturers have focused their attention on better resolutions, releasing products with "more and more megapixels!". Nowadays, there are digital cameras with 28 megapixels, which enables

users to print images with high resolution (300 dpi) and in sizes up to 52 x 39 cm. This feature is of utmost importance for professional photographers who constantly work with large sized images.

Some manufacturers, following the "megapixel fever", launch new products on the market without previous adequate testing. In addition to the number of pixels, other factors will influence the final quality of images, namely: the shape, size and layout of the pixels in the CCD digital sensor of the camera. This leads us to conclude that in order to obtain digital photographs with quality, it is important to use appropriate equipment with satisfactory resolution, excellent optical quality lens and ideal lighting systems.<sup>12</sup>

The subject of this research is of paramount importance, since digitizing radiographs by means of digital cameras is an effective and practical way to store data. In general, there is always an unstoppable quest for the most accessible and practical method and the fact that digital images can be shown to the patient on computer screens helps dentists build trust and credibility. This is a quick method that can be used on a daily basis in dental practice. Furthermore, we aimed at assessing the use of amateur digital cameras, since they are closer to the reality of most dental offices.

For these reasons, this study aimed at evaluating the required amount of megapixels that is necessary to obtain adequate quality of digital images when digitizing radiographs for alveolar bone loss assessment.

## Material and Methods

The research project was approved by the Institutional Review Board of Ingá University, under n° 0075/10. Ten periapical radiographs were selected from the archives of the Undergraduate Dental Clinics of Ingá University (UNINGÁ), Maringá, Paraná, Brazil.

The radiographs were digitized by three different amateur digital cameras (Sony Cyber-Shot DSC-W110, Fuji FinePix 2800HD, Sony Cyber-Shot DSC-T110) set at different megapixel resolutions. The cameras were statically positioned in front of a light box, with a standard distance of 60 cm.<sup>4</sup> The digitized images were imported into the Power Point XP for Windows software and the same radiographs were photographed by different digital camera models (Sony Cyber-Shot DSC-W110, Fuji FinePix 2800HD, Sony Cyber-Shot DSC-T110) and in different megapixel resolutions, such as; VGA (Video Graphics Array), 3 megapixels, 5 megapixels and 7 megapixels (Fig 1).

All images were viewed by examiners in an Intel Dual Core 2.2Ghz, 2Gb of RAM, 320GB of memory and a 19-in LCD screen computer, with calibrated brightness, contrast and distance.<sup>13</sup> The images were examined by five dental surgeons who classified their quality as good or poor for the evaluation of alveolar bone loss. The examiners assigned a numeric grade than ranged from 1 to 5 to the images, in which: 1 = Appropriate for diagnosis; 2 = Probably appropriate for diagnosis;

3 = Uncertain if appropriate for diagnosis; 4 = Probably inappropriate for diagnosis; 5 = Inadequate for diagnosis. Subsequently, the data were submitted to statistical analysis performed by the chi-square test ( $\chi^2$ ) with a significance level set at 5%. The software Microsoft Excel and Minitab 5.0 for Windows were used.

## Results

According to the methods adopted in this research, the following results were obtained:

The Sony W110 digital camera showed similar acceptable results, remaining constant for the studied resolutions: VGA, 3 megapixels, 5 megapixels and 7 megapixels (96.6%, 94.7%, 97.3% and 97.3% respectively) (Table 1). Moreover, the chi-square test at a significance level of 5% showed statistically significant differences between yes and no evaluations at all the studied resolutions. As for the Fuji FinePix camera, the highest values of acceptability started from a 3 megapixels resolution (96.6%) and the 7 megapixels resolution presented a 100% of acceptance. The Sony T110 digital camera started to present acceptable results at a 5 megapixels resolution (81.5%) (Table 1).

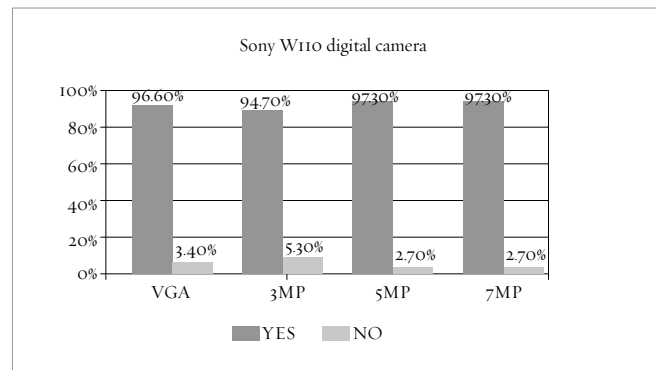
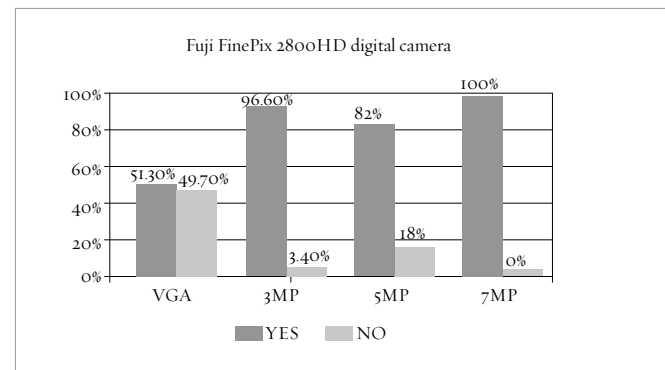
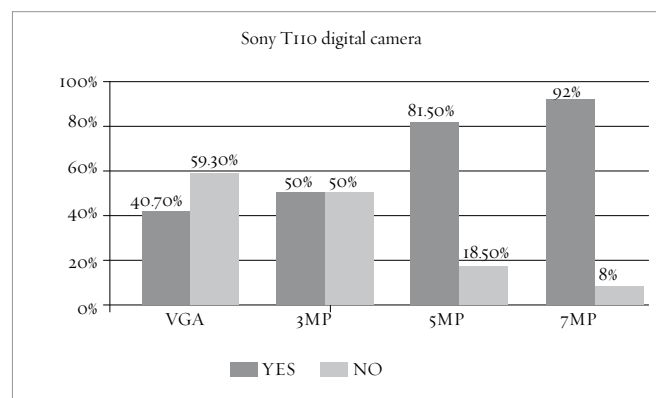


**Figure 1** - Radiographs digitized at 5MP with (A) Sony DSC-W110; (B) Fuji FinePix 2800HD and (C) Sony DSC-T110.

**Table 1** - Results of the examiners' answers to the question on whether or not the observed image is appropriate to assess alveolar bone loss.

Digital Camera	VGA		3 megapixels		5 megapixels		7 megapixels	
	Yes	No	Yes	No	Yes	No	Yes	No
Sony DSC W110	*96.6%	3.4%	*94.7%	5.3%	*97.3%	2.7%	*97.3%	2.7%
Fuji FinePix 2800HD	51.3%	49.7%	*96.6%	3.4%	*82%	18%	*100%	0
Sony DSC T110	*40.7%	59.3%	50%	50%	*81.5%	18.5%	*92%	8%

\*Statistically significant difference at 5% between answers on the same resolution.

**Figure 2** - Results of evaluation with Sony W110 digital camera.**Figure 3** - Results of evaluation with Fuji FinePix 2800HD digital camera.**Figure 4** - Results of evaluation with Sony T110 digital camera.

## Discussion

The current use of digital imaging is a result of scientific advancements that allow professionals to use it in previously unconceivable ways; assisting the diagnosis of malocclusions, the communication between professionals and their patients, and serving as an excellent tool to prospectively and retrospectively evaluate the evolution as well as the outcomes of periodontal treatment. It is also an excellent option for professionals who have a significant amount of records and want to digitize them so that documents that take a large amount of space can

be converted into digital files and stored in medias such as CDs (compact disks) or USB drives. The digitizing process with the use of scanners is slower and high-end equipment tends to be expensive. Digital cameras can perform the same process in a faster and adequate way, enabling immediate display of the images, which eliminates the cost of films and photo development.<sup>3</sup>

With this in mind, the present study aimed at evaluating the required amount of megapixels that is necessary to obtain adequate quality of digital images when digitizing and storing radiographs for alveolar bone loss assessment.

This study corroborates previous study results published by Machado et al<sup>11</sup> who suggest that the higher the image resolution, the higher is its detail definition, and consequently, the better tone, brightness and contrast it will have. Image resolution is directly proportional to the amount of pixels. That is, the greater the number of pixels (number of dots in the image), the better the image quality. This statement was proven correct in this study of which best results were obtained at highest resolutions. Machado et al<sup>11</sup> found that the versatility of digital cameras is unquestionable. Additionally, they claim that digital cameras are an excellent tool to digitize photographs, radiographs, dental casts and book pictures, replacing the use of scanners.<sup>11</sup>

According to the Webopedia,<sup>18</sup> the terminology "tone depth" is used to define the amount of distinct tones that a certain image features. This feature is often called "bit depth", because it is directly related to the number of bits used for each pixel to generate the tones. Therefore, the greater the number of pixels in an image, the greater the number of bits, and consequently, the greater the number of shades of gray that will favor the quality of the image. The results of the present study showed that the best images for alveolar bone loss<sup>9</sup> assessment were obtained by the Fuji FinePix digital camera, set at a 7 megapixels resolution.

This study showed that at a 5 megapixels resolution or higher, all evaluated digital cameras had adequate results for diagnosis (Fig 1). However, radiographs digitized at a VGA resolution were not adequate for diagnosis for the Sony T110 and Fuji FinePix 2800HD digital cameras (Figs 2, 3 and 4). According to the examiners, the Sony W110 digital camera presented adequate images for diagnosis in all studied resolutions; therefore, in addition to the resolution, the quality of the lens, the type of flash light, and the camera digital sensor may contribute to the final quality of a digital image (Fig 2).

According to Lemos et al<sup>10</sup> the photographic image has some disadvantages depending on the equipment chosen. Lenses, flash light, batteries, proper lighting and focal point can affect the final quality of the image. However, little is known in the literature about how to properly use photographic equipment, and there are no standard guidelines for digitizing radiographs.<sup>10</sup>

As reported by Bockert et al<sup>14</sup> the lens of a camera can produce image distortions, of which the most common are "barrel" and "cushion" distortions. The barrel distortion is a lens effect that causes images to seem inflated and it typically occurs at short end zoom lenses, in which the focal length is shortened. The cushion distortion is a lens effect that causes images to seem compressed at their center, and it is associated with long end zoom lenses, in which one focal length is greater. On both scenarios, the use of converters often amplifies the distortion. These defects can be better observed in images of perfectly straight lines, particularly when they are located close to the edge of the image. To most digital cameras, cushion distortions are less frequent than barrel distortions. The Adobe Photoshop<sup>14</sup> software can easily correct distorted images. The characteristics aforementioned may have influenced the results obtained by the three different digital cameras, despite having the same megapixel resolution.

Many studies approach image resolution subjects. Machado et al<sup>15</sup> described that the basic measurement unit of an image resolution is the pixel and the more pixels an image has, the greater its resolution will be, which was confirmed by this study.

The resolution of an image is also commonly measured by DPI (dots per inch). However, when digitally captured, every image is formed by PPI (or pixels per inch). Therefore, only when the image is printed it can be defined by DPI, because it ceases to be virtual and becomes physical.

According to Albenson et al<sup>16</sup> it is correct to say that an image was printed in DPI, but if it is seen on a computer screen, it should be defined as PPI. Albenson<sup>16</sup> suggests that although these two terms are theoretically different, in practice, they are used for the same goal. Branco et al<sup>17</sup> explain the meaning of DPI by affirming that when digitizing a picture with 300 DPI, for example, it is implied that each linear inch image contains 300 pixels and every square inch contains 90,000 (300 x 300) pixels, which will form the digital image. Therefore, we can conclude that the greater the amount of DPI, the greater the image resolution will be, and consequently, larger size files<sup>17</sup> (in bytes) will be created.

According to the Webopedia,<sup>9</sup> the resolution of an image depends on its DPI. When an image is digitized, it is divided into

various dots, named pixels. Even though they are sometimes referred to as dots, pixels have a square shape and are not round,<sup>9</sup> as the nomenclature suggests. Thus, when thinking about scanning an image, one must remember that the best quality (higher resolution) is closely associated with the use of a larger hard drive space. However, an image with a lower resolution has inferior quality.

With the recent shift in the digital paradigm, digital cameras have proved to be another option for digitizing and archiving radiographs. Furthermore, we chose amateur digital cameras to conduct this study with the purpose of increasing their clinical applicability in daily dental practice. However, additional studies are warranted to further investigate the use of these technologies.

## Conclusion

According to the methods adopted in this study, it can be concluded:

- 1) The best results were obtained with the Fuji FinePix 2800HD digital camera when set at a 7 megapixels resolution.
- 2) The three analyzed digital cameras presented satisfactory diagnostic results when set at a 5 megapixels resolution or higher.
- 3) The Sony W110 digital camera showed similar results for all three analyzed resolutions.

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