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*Professional paper*

# ANALYSIS OF MEAN GLANDULAR DOSE IN ONE DIGITAL MAMMOGRAPHY UNIT IN NORTH MACEDONIA

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**Abstract**

Mean glandular dose (MGD) represents a metric for quantifying the absorbed X-ray radiation by the breast glandular tissue during mammography procedures. The average glandular tissue dose is evaluated from the mean dose divided by the glandular tissue volume. Optimization in digital mammography ensures that the patients receive the lowest radiation dose feasible without deteriorating the diagnostic image quality. Despite the significance of this optimization, up to our knowledge, no studies have yet assessed the actual MGD of the Fuji Amulet S mammography system.
This study aims to estimate incident kerma for the Fuji Amulet S mammography system. The study aims at developing effective methods for reducing MGD without sacrificing digital image quality. The study presents findings from 400 patients undergoing mammography, a total number of 1600 mammograms at a North Macedonian facility, utilizing dose monitoring software (DOSE, QAELUM), both image data and survey responses were collected.
Median MGD, along with minimum and maximum values, were evaluated to be 1.73 mGy, 0.77 mGy, and 7.01 mGy, respectively. For the breast thickness range between 45 mm and 65 mm, the 25th and 75th percentiles for median MGD were evaluated to be 1.44 mGy and 2.04 mGy. These results suggest that the MGD values (in mGy) are somewhat lower than those outlined in European guidelines.

*Keywords:* DRLs, Mean Glandular Dose (MGD), Compressed Breast Thickness, Screening.

## 1. Introduction

Mammography has been the most effective method for early breast cancer detection. Mammography screening programs of health agencies (Governments) aim to lower the mortality of the female population due to breast cancer. Mortality reduction will be achieved by detecting breast cancer in its early (pre-symptomatic) stage, so that treatment can start earlier. Since the screening programs utilize ionizing radiation in mammography procedures, they should be done with care to acquire larger benefits than the radiation damage, and thus the risk for cancer occurrence. The radiation risk and the benefit from mammography screening can be determined by comparing the radiation risk and the number of deaths that can be avoided by early-stage cancer diagnostics.
The radiation dose from mammography could induce negative effects on the mammary tissue itself, increasing the risk of cancer. To assess the radiation risk from mammography, one should estimate the X-ray radiation dose received by the mammary tissue and the radiation effect at that given dose, considering the radiobiological sensitivity. The radiation dose from mammography can be assessed by measuring the mean glandular dose (MGD). Estimation of MGD can be achieved utilizing either a standard patient or a standard Mammo-phantom [1]. It has been previously established that increased breast thickness contributes to a higher average glandular dose. On the other side, increased breast compression during the mammography procedures reduces breast thickness, thereby lowering the radiation dose [2]. The primary objective of a mammography examination is to provide precise diagnostic information while

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delivering an acceptable dose to the breast organ, lowering the potential risk of cancer development [3].
To improve dose optimization in radiological examinations the International Commission of Radiological Protection (ICRP) recommends using so-called Diagnostic Reference Levels or DRLs [4]. A DRL is a dose level for a typical X-ray examination of patients of standard body size and broadly defined equipment types and brands. The tendency is for these levels not to be exceeded during standard procedures when good and normal practice is applied in diagnostic performance [5,6]. Implementing a DRL serves as a reference metric for monitoring image quality, aimed at standardizing and mitigating dose variations across various mammography imaging centers [7]. DRLs are considered essential parameters utilized for quality control, dose comparison of the different facilities, and optimizing diagnostic imaging. In mammography, the investigation of DRLs involves determining specific percentiles of the median mean glandular doses (MGDs) for each mammography unit that is subject to a survey [8].
Current digital mammography units use the possibility for Automatic Exposure Control (AEC) to select tube current, which changes MGD over a wide range, based on breast thickness and differences in breast tissue density. Understanding MGD and its dependence on breast thickness and tissue density is crucial for producing images with acceptable quality and the lowest possible dose.
The absorbed dose can vary greatly from procedure to procedure and from patient to patient, therefore it is very difficult to know whether a patient has received the optimized amount of radiation. By introducing diagnostic reference levels (DRLs) in mammography procedures it is expected that the optimization of protection in medical radiological practices, specifically in diagnostic imaging using ionizing radiation, is achieved. Diagnostic Reference Levels (DRLs) in diagnostic radiology are dose levels applied to typical examinations for either groups of standard-sized patients or standard phantoms. Herein, DRLs are not intended to set any dose limits. The concept of DRL is the optimization following the ALARA principle (As Low As Reasonably Achievable) dose in routine clinical practice. Diagnostic Reference Levels (DRLs) provide a measure of quality control and optimization of protection to help limit variations in dose delivered among various and within the same X-ray imaging centers and these levels are expected not to be exceeded for a standard diagnostic procedure in cases good and normal practice is applied [9].
In this study, we intend to determine the specific percentiles of MGD in one mammography unit from a diagnostic center in the Republic of North Macedonia and compare them with the respective values outlined in the European guidelines.

## 2. Methods

The study was conducted in one mammography centre in North Macedonia (NM) in which the patient dose monitoring software (DOSE, QAELUM) was installed. Women aged 30-89 years who attended mammography screening procedures in full digital mammography were part of this study. 400 patient examinations were acquired for the breast screening and diagnostic mammography and each examination recorded the four standard images, i.e. craniocaudal (CC) view and mediolateral oblique (MLO) view for each breast (right and left). Hence, this study is based on an analysis of 1600 mammographic projections (400 x 4 positions = 1600). The digital data were transferred from patient dose monitoring software (DOSE, QAELUM); data was extracted from the software and transferred to Microsoft Office Excel and Origin for further statistical analysis.

## 3. Results and discussion

The age of the patients ranged from 30-89, with a mean age of 55.57 years. Figure 1 shows the age distribution of the examined females in the Mammography unit, subject to this study.

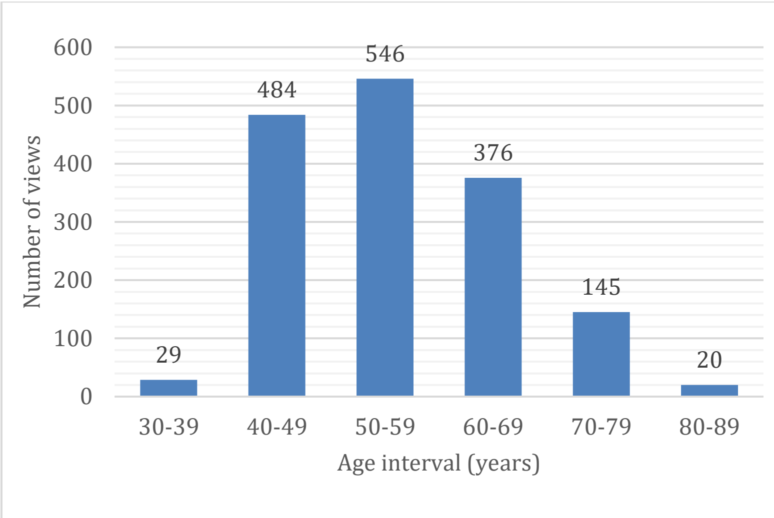


**Figure 1.** Total number of views in each of the Age intervals.

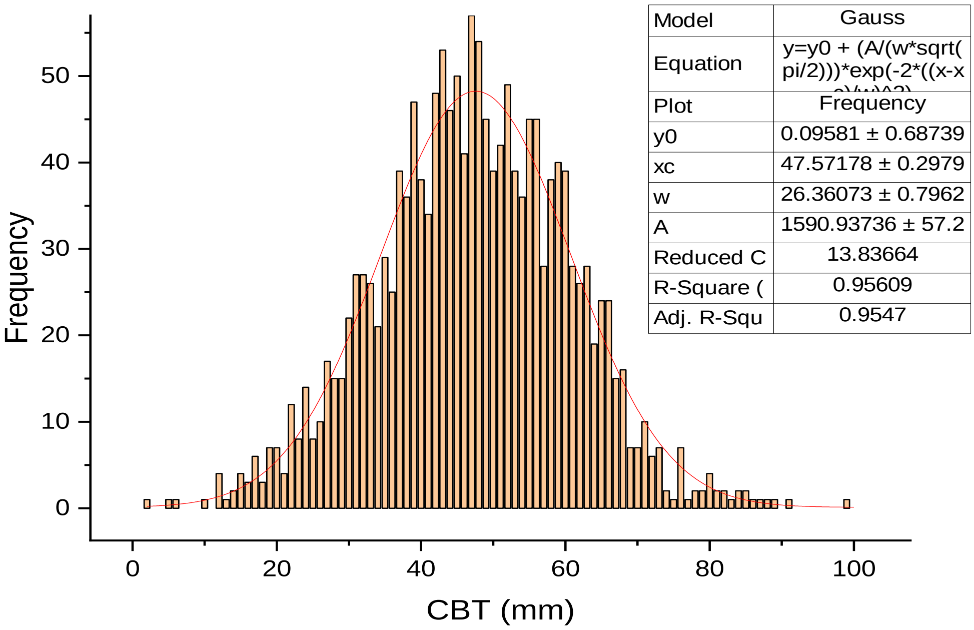


**Figure 2.** Frequency of occurrence of compressed breast thickness (CBT) for 1600 mammography images.

Figure 2 displays the histogram of the Frequency of occurrence of the compressed breast thicknesses CBT in mm, illustrating a normal (Gaussian) distribution with a mean of 47.3 mm.

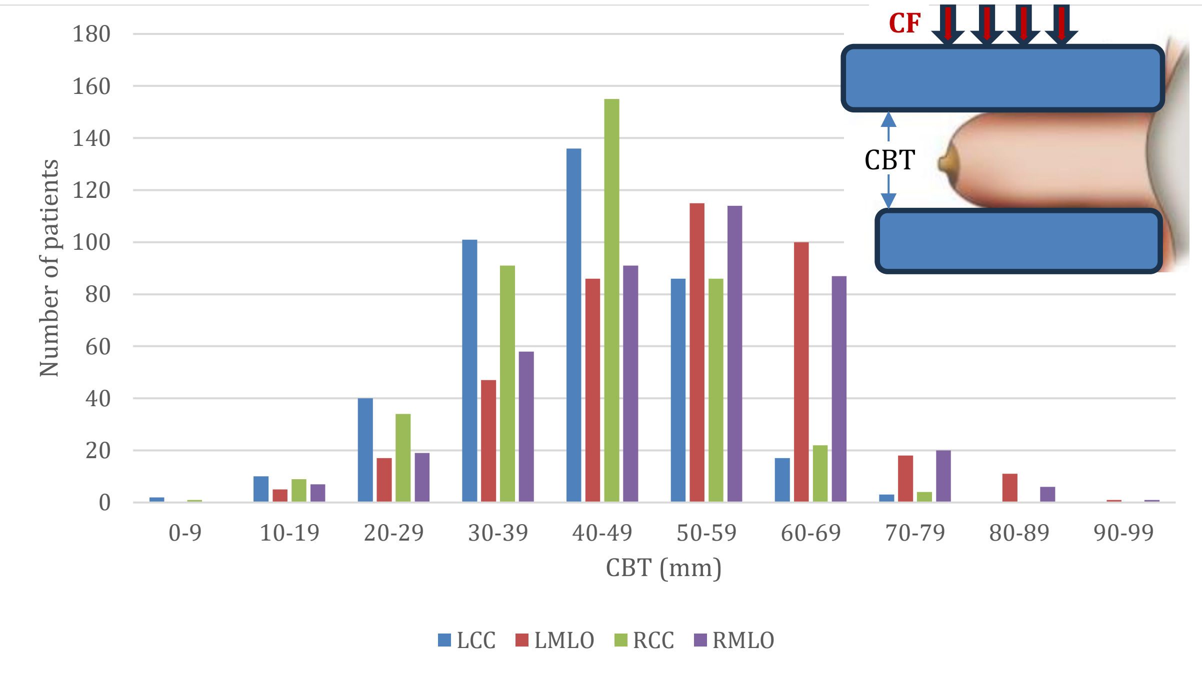


**Figure 3.** Histogram for CBT (mm) per image for 1600 views.

In Figure 3 CBT frequency distributions show the CBT's typical character for the CC and MLO views. The distribution of CBT in both views shows a normal distribution, with the peak of the MLO to the right of the CC view, indicating that the breast compressed for the MLO view tends to be thicker than when compressed for the CC view [10].

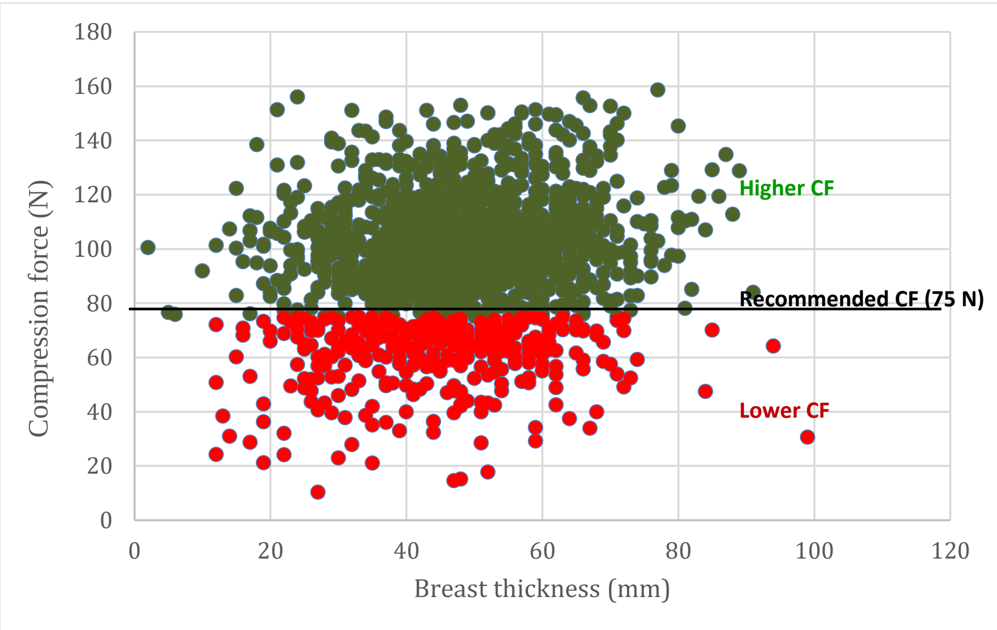


**Figure 4.** CBT (mm) as a function of compression force (N) for all projections.

The force applied to the breast during mammography should be big enough to ensure thickness is no longer a limiting factor for visualizing details in the breast, but also should be limited to a force that is tolerable for most women. It is optimal for the force to be sufficient to adequately thin the breast, but not so great that it causes excessive distortion of anatomic features. Figure 4 describes the histogram of compression force (CF) applied in all 1600 views, with a mean CF is 95.16 N ± 22.91 N for all projections and the value ranging between 10.4 N - 156.1 N. The average value of compression strength is 95.16 N, which is just above the acceptable minimum. Green data labels represent the occurrence of higher compression force than the recommended, while as red ones represent lower CF values than recommended (< 75 N).

**Table 1.** Statistical description of the included dataset (1600 mammograms).

| Thickness Range (mm) | Projections | Min dose MGD (mGy) | Median dose MGD (mGy) | Max dose MGD (mGy) | Std. Err. MGD (mGy) | Mean Thickness (mm) | Q1 | Q3 | IQR |
|---|---|---|---|---|---|---|---|---|---|
| 0 - 9 | 3 | 0.65 | 0.94 | 0.97 | 1.14 | 4 | 0.80 | 0.96 | 0.16 |
| 10 - 19 | 31 | 0.26 | 0.98 | 1.53 | 0.33 | 16 | 0.72 | 1.18 | 0.46 |
| 20 - 29 | 110 | 0.22 | 1.12 | 2.20 | 0.37 | 25 | 0.91 | 1.46 | 0.55 |
| 30 - 39 | 297 | 0.22 | 1.38 | 2.68 | 0.42 | 35 | 1.18 | 1.77 | 0.59 |
| 40 - 49 | 468 | 0.35 | 1.39 | 3.07 | 0.39 | 45 | 1.20 | 1.77 | 0.57 |
| 50 - 59 | 401 | 1.05 | 1.74 | 5.43 | 0.66 | 54 | 1.55 | 2.07 | 0.52 |
| 60 - 69 | 226 | 0.45 | 2.21 | 7.38 | 1.06 | 64 | 1.89 | 2.65 | 0.76 |
| 70 - 79 | 45 | 0.98 | 2.80 | 6.76 | 0.82 | 73 | 2.50 | 3.19 | 0.69 |
| 80 - 89 | 17 | 0.97 | 3.14 | 8.50 | 1.50 | 83 | 2.92 | 4.01 | 1.09 |
| 90 - 99 | 2 | 3.52 | 4.25 | 4.98 | 0.73 | 95 | 3.89 | 4.61 | 0.73 |

Table 1 presents the exposure and technical data acquisition for the 1600 examinations. It can be noted from Table 1, that the range of breast thickness is from 0-99 mm, an overall summary of the background data for each breast thickness range for minimum dose (mGy), maximum dose (mGy), median dose (mGy), standard deviation, mean thickness (mm), first quartile (Q1) and third quartile (Q3) and Interquartile range (IQR). The median MGD per examination for 400 women with a range of Compression Breast Thickness (CBT) was 1.63 mGy, with the smallest and highest doses delivered being 0.22 mGy and 8.5 mGy, respectively. Additionally, the lowest and highest median MGD values were 0.94 mGy and 4.25 mGy.

**Table 2.** Statistical analysis of the value of doses

| | Counts | Min MGD (mGy) | 25th MGD (mGy) | Mean MGD (mGy) | Median MGD (mGy) | 75th MGD (mGy) | Max MGD (mGy) |
|---|---|---|---|---|---|---|---|
| All | 1600 | 0.22 | 1.27 | 1.77 | 1.63 | 2.04 | 8.5 |
| 45-65 mm | 812 | 0.77 | 1.44 | 1.87 | 1.73 | 2.07 | 7.01 |

For the total of 1600 examinations, the calculated median (local diagnostic reference levels) was found to be 1.63 mGy, with the 25th percentile and 75th percentile at 1.27 mGy and 2.04 mGy, respectively. The minimum MGD recorded is 0.22 mGy, while the mean is 1.77 mGy. For patients with breast compression thicknesses (BCT) between 45-65 mm (812 examinations), the minimum MGD recorded is 0.77 mGy, and the mean MGD is 1.87 mGy. The calculated median (local Diagnostic Reference Levels) is 1.73 mGy, with the 25th percentile and 75th percentile at 1.44 mGy and 2.07 mGy, respectively.

In Figure 5 we present the mean MGD (mGy), assessed across compressed breast thicknesses ranging from 30-75mm for all the 1600 projections, encompassing Cranio-caudal (CC) and Medio-lateral oblique (MLO) views in a mammography unit in North Macedonia. Notably, MGD compliance with DRLs falls below the European DRL acceptable (mGy), European DRL achievable (mGy), and Belgian DRL (mGy).

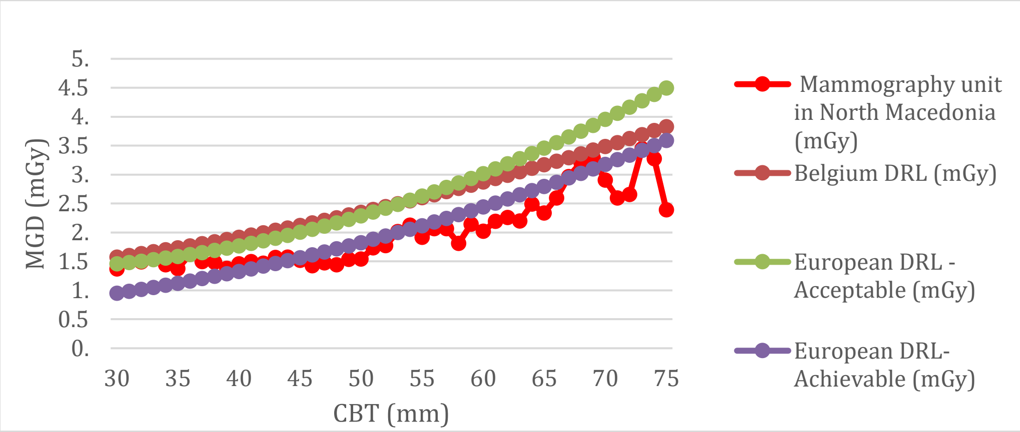


**Figure 5.** DRLs (mGy) for patient studies categorized by Compressed Breast Thickness (CBT).

## 4. Conclusion

It's important to note that DRLs are a part of the optimization process, serving as general guidelines for clinical operations rather than directly applying to individual patients or exams [11]. In this study, dose data for each projection was collected using dose monitoring software (DOSE, QAELUM) and transferred to Microsoft Office Excel. The average Mean Glandular Dose (MGD) was calculated for each Compression Breast Thickness (CBT) ranging from 30 mm to 75 mm across 1600 projections, including Cranio-caudal (CC) and Medio-lateral oblique (MLO) views. The study assessed the MGD found for the examined Mammography unit compliance with Acceptable European, European Achievable and Belgian diagnostic reference levels obtained from the software. The study found that MGD values in the mammography unit for higher thicknesses (CBT values) are lower than those reported by Belgium institutions and both achievable and acceptable values outlined in European guidelines.

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