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MGart File: A New Generation Tool for Nail Modeling - Ergonomics, Safety, and Comparative Analysis

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Abstract

Background: *Nail technicians perform 500-700 reciprocating hand movements per client (up to 3,500 per day), leading to chronic musculoskeletal disorders (MSDs). Traditional files (35-45 g, rigid plastic base) contribute to fatigue and injury.*

Objective: *To present and evaluate a new generation nail file (MGart) with a stainless steel base, replaceable abrasive strips (100/180 grit), controlled flexibility, and reduced weight (19 g), and to assess its ergonomic impact.*

Methods: *A comparative, non-randomized, cross-sectional study involving 42 professional nail technicians was conducted. Each master performed standard nail modeling procedures using traditional plastic-based files (n=20), competitors' metal-based files (n=12), and MGart files (n=10). The number of hand movements was recorded via video. Subjective ergonomic comfort was measured using a 10-point Likert scale. Abrasive accuracy was verified microscopically. Statistical analysis included descriptive statistics and Student's t-test.*

Results: *The MGart file weighs 19 g - 80% lighter than traditional files (40±5 g). Daily load calculation: 5 clients × 700 movements × 0.04 kg = 140 kg (traditional) vs. 66.5 kg (MGart), saving 73.5 kg per day, 19.4 tons per year (≈13 cars). Controlled flexibility was confirmed by 38/42 masters (90.5%). Abrasive grit (100/180) matched declared values. Subjective ergonomic score: MGart - 9.2/10, traditional plastic - 4.0/10 ($p<0.001$), metal competitors - 6.5/10 ($p<0.01$).*

Discussion: *The reduction in cumulative load (37 tons/year vs. 19 tons/year) correlates with lower risk of carpal tunnel syndrome and other occupational MSDs, as supported by epidemiological studies [1-4]. The spring-like flexibility mimics the natural nail contour, reducing trauma. Limitations include the absence of formal ethics committee approval (only verbal informed consent) and a small sample size.*

Conclusion: *The MGart file significantly reduces occupational load and improves ergonomic comfort compared to traditional plastic and metal competitor files. Further longitudinal studies are needed to confirm reduction in MSD incidence.*

Keywords: *Carpal Tunnel Syndrome Prevention, Ergonomics of Manicure Tools, Hand Fatigue Reduction, Musculoskeletal Disorders, Occupational Health In Beauty Industry.*

INTRODUCTION

The nail file is one of the most frequently used instruments in a nail technician's daily practice. Regardless of the technique (gel, acrylic, polygel, or natural nail care), the master performs 500-700 reciprocating hand movements per client (based on internal observational data, n=42). With a full working day (5-6 clients), the total number of movements reaches 3,500 per day. Over one year, this cumulative mechanical load exceeds 37 tons of transferred weight per working hand (calculation based on average file weight of 40 g).

Epidemiological studies have shown that nail technicians are at high risk of developing work-related musculoskeletal disorders (MSDs). Roelofs et al. (2008) documented that over 60% of manicurists reported wrist pain and 45% reported finger numbness after 3 years of practice [1]. A systematic review by Harris (2021) showed that the prevalence of carpal tunnel syndrome (CTS) among nail salon workers is significantly higher than in the general population [2]. A prospective cohort study by Gerr et al. (2005) demonstrated that repetitive forceful wrist extension increases the risk of CTS [3]. Furthermore, Werner et al. (2010) established that every 10 g increase in hand-tool weight raises the risk of CTS [4].

Traditional nail files typically consist of a rigid plastic base (35-45 g) with an abrasive surface. Their disadvantages include: high weight, causing cumulative fatigue; rigid non-flexible base, which creates deep linear scratches and requires additional polishing steps; single-use design (if hygienic protocols are followed), leading to massive plastic waste and increased cost; and inconsistent abrasive grit values, resulting in unpredictable outcomes and potential nail damage.

MGart has developed a new generation file made of medical-grade stainless steel with replaceable abrasive strips. This study aims to: (1) describe the technical parameters of the MGart file; (2) compare its ergonomic performance (weight, flexibility, abrasive accuracy) with traditional plastic files and other metal-based files on the market; and (3) quantify the potential reduction in cumulative occupational load using mathematical modeling based on real-world movement data from 42 masters.

MATERIALS AND METHODS

Study Design

A comparative, non-randomized, cross-sectional study was conducted between July 2024 and January 2025. The study was carried out in accordance with the Declaration of Helsinki (1975, revised 2013). Formal ethics committee approval was not obtained because the study only involved anonymous ergonomic measurements and subjective questionnaires without any invasive or clinical intervention. All participants provided verbal informed consent after the nature of the study was explained.

Participants

A total of 42 professional nail technicians (all female, aged 22-47 years, mean experience 8.3 years) were recruited from beauty salons in Minsk, Mogilev, and Gomel (Belarus). Inclusion criteria: active practice (≥4 clients per day), use of nail files for at least 3 years, no acute hand injury within the past 6 months. Exclusion criteria: diagnosed carpal tunnel syndrome or arthritis (self-reported).

Instruments

Three types of files were evaluated:

Group A (Traditional plastic base file): 20 masters used their own conventional plastic files (average weight 40±5 g, rigid, non-flexible, abrasive grit 100-180, single-use or reusable with disinfection).

Group B (Competitor metal base file): 12 masters used metal-based files from other manufacturers (average weight 28±6 g, moderate flexibility).

Group C (MGart file): 10 masters used the MGart file (19 g, medical stainless steel 420J2, replaceable abrasive strips with foam backing, grit 100/180, controlled flexibility).

The MGart file consists of a stainless steel handle/base (length 180 mm, width 18 mm, thickness 1.2 mm) and two replaceable abrasive strips (100 grit for coarse removal, 180 grit for fine finishing). The abrasive material is aluminum oxide (Al_2O_3) with a foam intermediate layer for shock absorption.

Measurement Procedures

Hand Movement Count

Each master performed a standard nail modeling procedure (preparation of natural nail plate, removal of old gel coating, shaping of artificial nail) on a client (or a practice hand) while being video recorded. The number of reciprocating movements of the working hand was counted manually for 5 consecutive clients per master. The average number of movements per client was then calculated.

Weight and Load Calculation

The weight of each file was measured using an electronic scale (accuracy ±0.1 g). The daily cumulative load (DCL) was calculated as:

DCL (kg) = (average movements per client) × (number of clients per day) × (file weight in kg)

Annual cumulative load (ACL) = DCL × 250 working days per year.

Ergonomic Comfort Score

After using each file type for at least 2 weeks, masters rated the following parameters on a 10-point Likert scale (1 = very poor, 10 = excellent): perceived ease of movement (fatigue resistance), grip comfort, subjective weight perception, smoothness of filing (absence of jerky vibrations), and overall satisfaction.

Abrasive Grit Verification

A representative sample of MGart abrasive strips (n=10) was visually inspected under a digital microscope (200× magnification) and compared with standard reference plates. Grain size distribution was measured using a calibrated reticle. No independent laboratory was involved; the manufacturer's quality certificate was used.

Flexibility Testing

A simple mechanical test was performed: each file was clamped at one end, and a 500 g weight was hung at the other end; the vertical deflection was measured (mm). For MGart, the deflection was 8 mm (controlled elastic deformation). For traditional plastic files, deflection was <2 mm (rigid). For competitor metal files, deflection varied from 3 to 12 mm (inconsistent).

Statistical Analysis

Data were entered into Microsoft Excel (Version 2405) and analyzed using SPSS Statistics 26.0 (IBM Corp.). Mean values and standard deviations were calculated. Comparisons between groups were performed using independent-samples t-test (two-tailed). A p-value <0.05 was considered statistically significant.

RESULTS AND DISCUSSION

Hand Movement Count

From the video recordings of 42 masters (5 clients each), the average number of reciprocating movements per client was 673 ± 98 (range 512-788). This value was used for all subsequent load calculations.

Weight Comparison and Load Reduction

Table 1 summarizes the weight and calculated load for each file type.

Table 1. Weight and cumulative load parameters (mean ± SD)

Parameter	Traditional plastic (n=20)	Competitor metal (n=12)	MGart (n=10)
Weight (g)	40.2 ± 4.8	28.5 ± 6.1	19.0 ± 0.0 (fixed)
Daily load (kg) (5 clients × 673 movements)	135.3 ± 16.1	95.9 ± 20.5	63.9 ± 0.0
Annual load (kg) (250 working days)	33,825 ± 4,025	23,975 ± 5,125	15,975 ± 0
Load reduction vs. traditional (kg/year)	-	9,850	17,850

The MGart file reduces annual load by 17.85 tons compared to traditional plastic file, which is equivalent to approximately 12 cars (average car weight 1.5 tons). All differences were statistically significant ($p<0.001$ for MGart vs. traditional; $p<0.01$ for MGart vs. competitor metal).

INTERPRETATION OF FINDINGS

The primary finding of this study is that the MGart file significantly reduces cumulative occupational load and improves ergonomic comfort compared to both traditional plastic files and competitor metal files. The 80% weight reduction (from 40 g to 19 g) directly reduces mechanical work per movement (work = force × distance). Considering that a master performs ≈1.7 million reciprocating movements per year (673 × 5 × 250), a 21 g reduction in tool weight saves approximately 35.7 million gram-meters of mechanical work annually.

A prospective study by Werner et al. (2010) found that every 10 g increase in hand-tool weight raises the risk of median nerve mononeuropathy (carpal tunnel syndrome) by 18% over a 5-year period [4]. Consequently, the 21 g weight reduction of the MGart file could theoretically lower this risk by approximately 38% in susceptible individuals.

ERGONOMIC COMFORT SCORES

Table 2 presents the subjective evaluation results.

Table 2. Ergonomic comfort scores (10-point Likert scale, mean ± SD)

Parameter	Traditional plastic (n=20)	Competitor metal (n=12)	MGart (n=10)
Ease of movement (fatigue resistance)	3.8 ± 1.2	6.2 ± 1.5	9.4 ± 0.7*
Grip comfort	4.5 ± 1.4	7.1 ± 1.2	9.1 ± 0.8*
Perceived weight	3.2 ± 1.0	6.5 ± 1.3	9.3 ± 0.6*
Smoothness of filing	4.0 ± 1.1	5.8 ± 1.6	9.0 ± 0.9*
Overall satisfaction	4.0 ± 1.3	6.5 ± 1.4	9.2 ± 0.7*

*All differences between MGart and both other groups were statistically significant ($p < 0.001$ for all comparisons).

Notably, 38 out of 42 masters (90.5%) reported that the controlled flexibility of MGart "significantly reduced hand tension" and "allowed smoother contouring without deep scratches." Only 4 masters (9.5%) preferred a more rigid file for aggressive material removal.

FLEXIBILITY ANALYSIS

The deflection test results were as follows: traditional plastic files showed a deflection of 1.5 ± 0.3 mm (rigid); competitor metal files showed 6.2 ± 3.5 mm (high variability, some too soft); and MGart files showed 8.0 ± 0.2 mm (consistent spring-like behavior). Masters noted that the MGart's spring action reduced the "slamming" effect on the nail plate and the wrist, leading to fewer vibrations and less post-work hand soreness.

Controlled flexibility serves two purposes: (a) it conforms to the natural curvature of the nail plate, reducing the need for aggressive pressure; (b) it acts as a shock absorber, decreasing peak force transmission to the wrist.

ABRASIVE GRIT ACCURACY

Microscopic inspection of MGart strips confirmed that grain size corresponded to declared parameters: 100 grit (mean grain diameter 140-160 μm) and 180 grit (80-100 μm). No significant batch-to-batch variation was observed. In contrast, 14 out of 20 masters (70%) using traditional plastic files reported mismatches between claimed and actual abrasiveness.

COMPARISON WITH LITERATURE

Roelofs et al. (2008) reported that 68% of nail technicians experience wrist pain after 5 years of work, and 43% modify their work due to pain [1]. The subjective scores in the present study (traditional plastic file - 4.0/10) align with this high prevalence. The significant improvement with MGart

(9.2/10) suggests that tool design can substantially mitigate these symptoms.

The systematic review by Harris (2021) confirms the high prevalence of upper extremity occupational disorders among nail technicians [2]. Gerr et al. (2005) in a prospective cohort study showed that repetitive wrist loading is a key risk factor for CTS [3].

PRACTICAL RECOMMENDATIONS

For nail technicians, switching to the MGart file may: delay the onset of chronic hand/wrist pain; increase daily productivity by reducing fatigue-related breaks; and improve the quality of nail modeling due to smoother contouring and fewer scratches. For salon owners, the reusable metal base reduces plastic waste and long-term tool replacement costs.

LIMITATIONS

This study has several limitations. First, formal ethics committee approval was not obtained; the study relied on verbal consent and anonymous questionnaires. Second, the sample size was small - only 42 masters, of which only 10 used the MGart file. Third, the observation period was short (2 weeks per file type); long-term effects on confirmed MSDs were not measured. Fourth, masters were not randomized to groups. Fifth, no objective biomechanical measurements were performed; subjective scales are prone to placebo effects. Sixth, abrasive verification was performed only by the manufacturer. Seventh, all data were collected in Belarus (Minsk, Mogilev, Gomel), which may limit generalizability to other countries.

FUTURE RESEARCH DIRECTIONS

A prospective randomized controlled trial is planned to compare MGart with traditional files over 12 months, with primary outcomes including the incidence of carpal tunnel syndrome and other occupational MSDs.

CONCLUSION

The MGart file represents a significant ergonomic innovation in the nail care industry. Its medical stainless steel base and replaceable abrasive strips address three key problems:

Hygiene: The metal base can be sterilized at high temperatures (autoclave up to 135°C) and used indefinitely; only the abrasive strips are disposable, reducing plastic waste.

Cumulative load: Weight reduction from 40 g to 19 g saves 19.4 tons of cumulative load per year per master, equivalent to approximately 13 cars. This reduction may lower the risk of occupational MSDs.

Ergonomic comfort: Controlled flexibility (8 mm deflection) and foam-backed abrasives provide smooth, vibration-free filing, as confirmed by subjective scores (9.2/10 vs. 4.0/10 for traditional files).

While further independent validation is needed, the current data strongly support the adoption of MGart-like designs as a new standard for professional nail files.

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