THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N°. 4 - 2023, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2023.4.03

COMPARATIVE STUDY OF SOME MATERIALS USED IN NAIL PLATE PROSTHESIS

Rodica MUȘALĂ, Vasile BRIA, Elena Emanuela HERBEI, Daniela-Laura BURUIANĂ, Viorica GHISMAN, Marius BODOR*
"Dunarea de Jos" University of Galati, Romania
*e-mail: marius.bodor@ugal.ro

ABSTRACT

Nails are involved in most everyday activities, whether physically for seemingly simple actions such, protection against external factors or roles with an aesthetic implication, for the integration of people into society. Often, any change at an aesthetic level is felt both from the point of view of the patient, who can be affected at a psychological level, feeling anxiety due to the lack of a part considered essential, and from the point of view of society that imposes a certain standard to be accepted in the community. Because of this societal standard, people with an untreatable nail deformity or disease can feel marginalized and excluded. Recently, an important number of studies have been carried out in this field, especially since the uses of polymeric materials have gained a wide field of applicability.

In this work, the comparison between three types of polymeric materials used in salon work was highlighted, for the aesthetic treatment of some diseases with a long healing time or even untreatable, by making prostheses for the affected nail plates of onycholysis. The mentioned materials were analysed microscopically, tested for roughness and hardness, and tested for compression and bending resistance, in order to understand how a nail prosthesis made of these materials behaves under different actions and external factors to which the nails are subjected to in daily activities. Finally, the method of making a nail prosthesis from one of the tested polymeric materials was presented and the importance of the functions of the nails, both aesthetic and medical, was highlighted.

KEYWORDS: nail plates, optical microscopy, hardness, roughness, mechanical testing, polymeric materials

1. Introduction

The nail is a semi-hard blade made up of several keratin cells that give it hardness [1]. A nail consists of several main elements, six in number: *The germinal matrix* - also called the root, is the most important part of the nail, because it produces onychoblast cells that over time develop and give rise to new cells, called onychocytes that migrate forward towards the distal nail fold. These onychocytes become harder keratin cells over time [1, 2]; *Lunula* - is the segment that shows the end of the germinal matrix. All nails have this area, but it is not visible on everyone equally [3]; *The nail bed* - is the area between the lunula and the hyponychium [4]; *Eponichium* - is located between the skin and the nail bed [5]. This structure provides the fingers with a superior barrier against microorganisms [6]; *Hyponychium* - It is the epithelial tissue between the nail plate and the tip of the finger, it is present between the free tip of the nail and the distal fold of the nail bed [7]. This epithelium is very rich in white and red blood cells and forms a seal against external microorganisms [5]; *Perionychium* - it is the tissue that covers the nail plate on the sides and has the same role as the hyponychium and eponychium [5, 7]. The nail plate is embedded in the folds or lateral folds of the finger. These being most often more prominent in the case of toenails [5]. If at birth, or during life this fold, together with the surrounding and protective layers of the matrix are damaged, there is a risk of a permanent defect of the nail [5]. The thickness of nails in a healthy adult varies from 0.5 mm to 0.75 mm, and in the case of toenails, greater than 1 mm. The rate of nail growth varies from 0.5 mm to 1.2 mm per week and the growth is continuous

THE ANNALS OF “DUNAREA DE JOS” UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N°. 4 - 2023, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2023.4.03

[8]. External factors, trauma, manicure, inflammation or infection can cause cuticle loss, this situation implies a difficulty of the proximal fold to protect the nail matrix [3, 9].

Due to external factors, nails are subject to a high risk of disease, being in the first line of contact with the external environment [9]. In this sense, the nails can suffer from a variety of diseases, depending on the cause, symptoms, but also on the way of formation. Nail conditions are not only aesthetic problems, but these problems can also indicate systemic diseases or show signs of infection in the body [10]. Some of the most common nail diseases are: onycholysis, onychomycosis, paronychia, pseudomonas, nail psoriasis, Beau's lines. These diseases have different causes: inflammatory, infectious, traumatic etc. [10].

There is the possibility that some of the nail diseases cannot be treated medically, due to the process of traumatizing the nail plate or the nail matrix. So, to improve the quality of life of patients, it was decided to solve aesthetic problems with the help of cosmetic products [11]. The most well-known materials used are nail varnishes, which are applied over a base layer, usually colourless, which has the role of fixing the next material and smoothing the irregularities of the nail plates, followed by the coloured layer and finally a protective, transparent layer which provides shine and prevents premature damage or chipping [11]. Most air-dry varnishes contain the following components:

- 15% film former, usually nitrocellulose which is a non-sensitizing, waterproof component that adheres to the nail plate;
- 7% thermoplastic resin (Toluene Sulphonamide Formaldehyde Resin - TSFR, which enables and strengthens the adhesion, hardness and flow of the material);
- 7% plasticizer, usually dibutyl phthalate and camphor, which improve flexibility and prevent shrinkage;
- 70% solvent-extender (toluene, butyl, or ethyl acetate and isopropyl alcohol, which allow the other components of the nail polish to remain liquid);
- 0-1% pigment;
- 1% suspending agent [11].

In the case of structural defects, such as Beau's lines, or trauma in the matrix area, polymer products have been developed that harden in contact with liquid monomers or ultraviolet radiation. There are two types, acrylic nails being the first type which is represented by a paste made of a liquid monomer, ethyl methacrylate and a powder polymer, polymethyl methacrylate that harden at room temperature with the help of an organic accelerator (benzoyl peroxide) forming a paste that is applied to the nails [11]. The second type, gel nails, are a mixture of ethyl cyanoacrylate and polymethyl methacrylate - the monomers are combined with the same powder polymer as the liquid acrylic nail which requires ultraviolet radiation to polymerize and harden [12].

The materials used in nail plate prosthetics, with the help of ultraviolet radiation, are composed of several substances, the main substance found in these products is methacrylate acid, a product with the following chemical formula: $CH_2=C(CH_3)COOH$ [13]. It is found in liquid or solid form but with a very low melting point. When in liquid form, it is colourless, and has a pungent odour [14]. In addition to the methacrylate acid, other components can be found, as for example: titanium dioxide – TiO_2, ethyl methacrylate - $C_2H_5O_2CC=CH_2$, trimethylolpropane triacrylate - $C_{15}H_{20}O_6$, polydimethylsiloxane - $CH_3[Si(CH_3)_2O]nSi(CH_3)_3$, methyl methacrylate - $CH_2=C(CH_3)COOCH_3$, hydroxyethyl methacrylate - $H_2C\backslash dC(CH_3)CO_2CH_2CH_2OH$, polyethylene terephthalate - $(C_{10}H_8O_4)_n$, 1-Hydroxycyclohexyl Phenyl Ketone - $C_{13}H_{16}O_2$, silicon dioxide – SiO_2 and wax, all of which having various functions.

The aim of the present work was to identify the best option for the restoration of a nail plate, choosing from three options, based on the results obtained from morphological testing, roughness, hardness, but also from a mechanical point of view using traction and compression testing.

2. Materials and methods

As part of the experimental part, 3 polymer materials used in nail plate prosthetics in manicure salons were chosen. These polymeric materials were inserted into straws of the same diameter, and length, to obtain the samples for the following analyses. After introducing the polymeric substance into the straws, they were placed in the 36 W UV lamp (λ = 356 nm) for 5 minutes (Figure 1), as this material becomes solid only in contact with ultraviolet rays. These polymer materials have in their composition photo initiating substances, which in contact with ultraviolet rays, produce heat and strengthen the polymer becoming solid.

Figure 1 shows the polymer material inserted into the straw under the UV lamp to polymerize the material and obtain the samples. After 5 minutes, the straws were removed and the samples were placed again under the UV lamp for another 2 minutes, to ensure the total polymerisation of the samples. At the end of polymerization, the samples were removed from the UV lamp and notated.

Figure 2 shows 2 samples of each polymer material used in the laboratory tests. The materials come from 3 different companies of polymer products: Kinetics, Gliterro and Macks, noted in the

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N°. 4 - 2023, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2023.4.03

experiments with the letters K, G, M. From these samples, two sections with lengths between 12-14.5 mm were extracted, used later in the mechanical tests to observe their resistance to compression and bending, and a cylindrical section of 2 mm each for the microscopic analysis. All samples had an equal diameter of 5.85 mm (Fig. 3).

Fig. 1. *UV curing process of the samples*

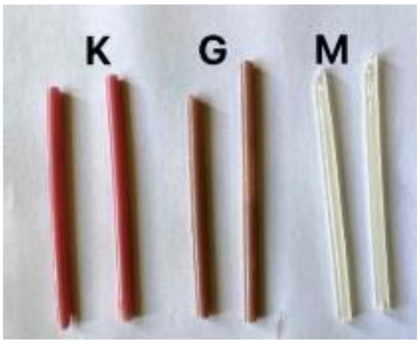

Fig. 2. *Obtained samples after UV-light curing*

Fig. 3. *The diameter of the specimens measured with a calliper*

After obtaining the samples, the microscopic analysis of the materials followed. For this analysis the inverted metallurgical microscope Kern OLM 171 was used. This microscope features a powerful and infinitely adjustable 50 W halogen incident light illumination, which ensures optimal illumination of the materials being analysed. This type of microscope is equipped with a trinocular tube, a simple polarizing unit consisting of an analyser and a polarizer, and a mechanical stage [15]. The microscope specifications offer magnification powers of 50x, 100x, 200x, and 500x. The interpupillary distance is 48-76 mm and the viewing position through the eyepiece is made at 30°. In the present case, a computer connected camera was used to capture images.

To analyse the roughness of the polymer materials used in nail plate prosthetics, an Insize ISR-C002 portable roughness meter was used. This roughness meter measures 21 roughness parameters. The obtained values are displayed on a digital screen

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N°. 4 - 2023, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2023.4.03

for roughness, the profile and the curve and has the capacity to store 100 values. It can be connected via USB to a printer. As technical specifications, the Insize ISR-C002 roughness meter has an accuracy of +/- 10%. The material from which the probe is made is diamond and the probe is of inductive type. The roughness measurement force is 4 Nm. The number of interpenetrations is between 1 and 5. The device has two crossing speeds, namely: 0.5 mm/s and 1 mm/s [16].

For Vickers hardness testing, the Insize Micro-Vickers ISH-TDV1000A hardness tester was used. This device is used to measure the hardness of a small sample of material. Thanks to software based on Vickers hardness calculation, the obtained value can be converted, and the value of Rockwall hardness can be found. The device consists of a support table, mechanical, adjustable horizontally and vertically, two objectives that allow observing the sample before activating the indenter and after making the impression in the sample. The objectives have a magnification power of 10x or 40x and for the analysis carried out in this study, the 10x objective was chosen. The device also contains a camera connected to the eyepiece through which manually drawn axes are observed, according to the imprint of the indenter in the sample (Figure 4). The specifications of the durometer offer the possibility of changing the force, with the following options: 0.01, 0.025, 0.05, 0.1, 0.2, 0.3, 0.5 and 1 N. The charging time of the device varies between 5-60 s. For the Vickers hardness test, thin lamellae were obtained from each polymer materials used in this study.

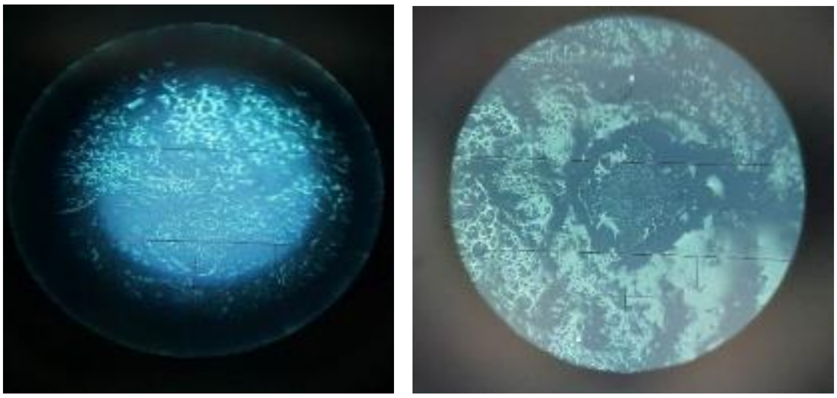

Fig. 4. *The surface of a K material sample before hardness testing – left image and a print in the same sample, framed by the measuring axes – right image*

Mechanical testing was performed using an Instron 8850 servo-hydraulic testing machine. The Instron 8850 series testing system is a dynamic, servo-hydraulic, floor-mounted, biaxial machine that provides axial torsional loading on the test specimens, in an integrated biaxial actuator. This instrument fulfils the material verification requirements with a wide testing range, biaxial static and dynamic [17]. The Instron 8850 system has a capacity of about 100 kN, and a torque capacity of about 1000 Nm, with an axial stroke of the actuator motor of 150 mm and a rotational stroke of 90° [18]. The first test of the polymeric materials used in this study, was the 3-poin bending test. For this purpose, the specimens were placed on the Instron 8850 system which had a support distance of 50 mm and the lowering speed of the action bar of 5 mm/minute. Two rounds of testing were performed for each polymer material. Fig. 5 offers three image captures showing an ongoing bending test for a sample made of the M material.

The next mechanical test was the compression testing, using the same test system, the Instron 8850 with a modified clamping system as seen in Figure 6.

The samples used for the compression testing were cut from the original samples and then polished to obtain flat surfaces. After the polishing, the samples lengths were measured with a calliper (Fig. 7) then tested using a descent of the upper platen of 1.3 mm/minute.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N°. 4 - 2023, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2023.4.03

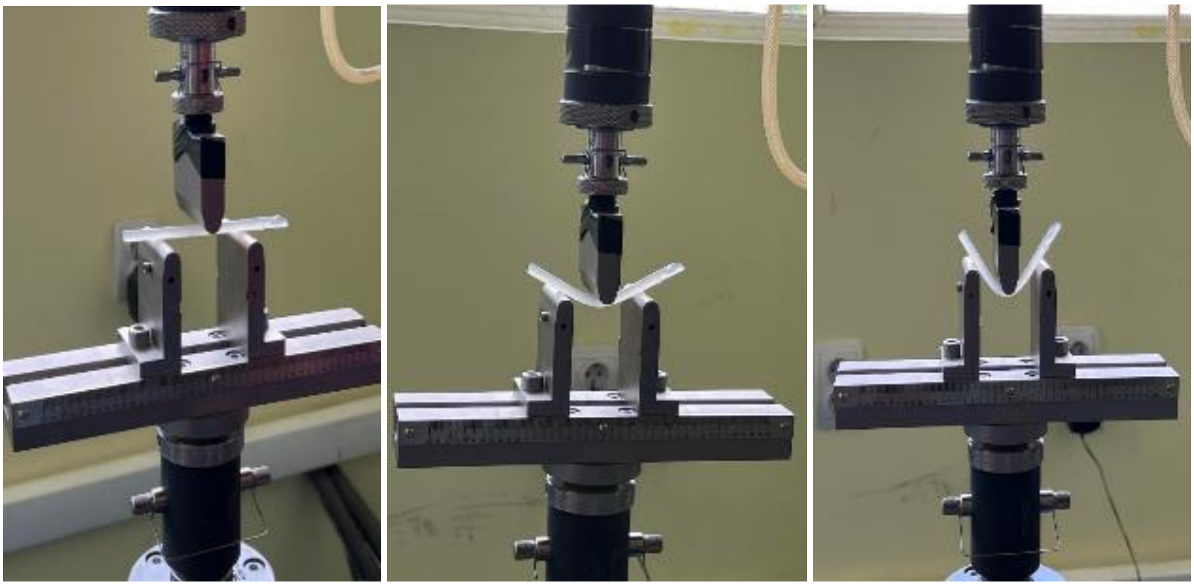

Fig. 5. *Image captures during the 3-point flexure test of a M material sample*

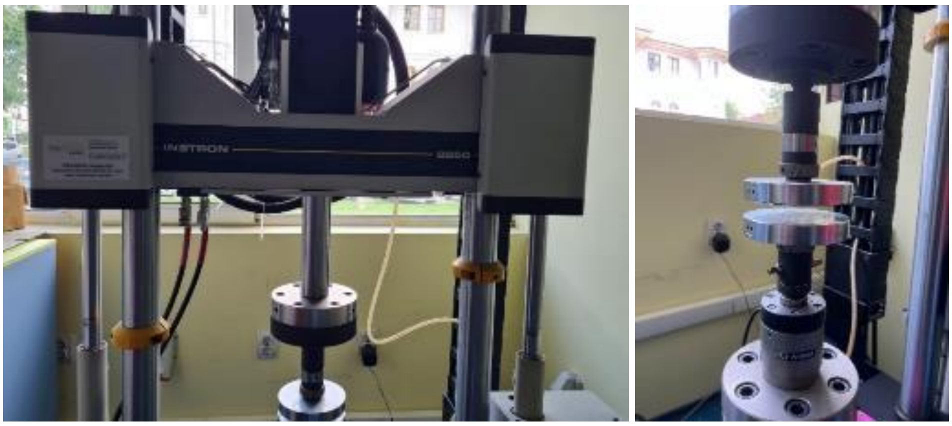

Fig. 6. *The Instron 8850 mechanical test system with a clamping architecture used for compression testing*

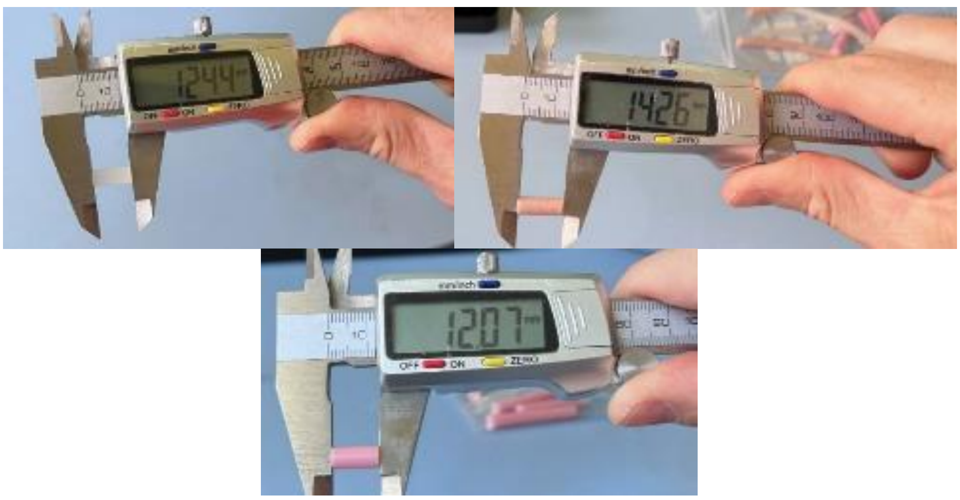

Fig. 7. *Measuring the length of test specimens for compressive strength testing*

3. Results and discussions

3.1. Optical microscopy

Following the microscopic analysis performed with the Kern OLM 171 microscope, a magnified image of each tested sample was obtained. These images show the structure magnified at 50x (Figure 8).

The obtained images emphasize the first differences between the tested materials. Thus, the K material presents ramifications and perforations with a spongy appearance, while the M material presents a compact and more uniform structure, compared to the K material, but at the same time with many interspersed vesicles. Meanwhile, the G material stands out from the point of view of the microscopic image due to the lack of gaps and the reflections provided by the silicon dioxide. Thanks to the silicon dioxide, the quartz particles used for light diffusion and for aesthetic purposes are easily visible in this last tested material. In addition, this material, compared to the others, does not have perforations or a branched structure, but a uniform one.

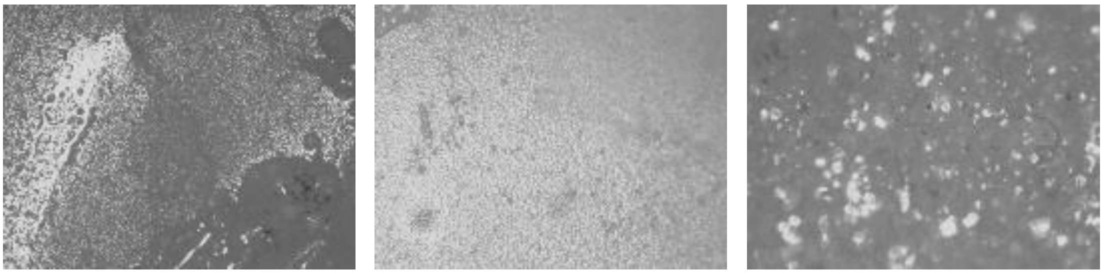

Fig. 8. *Microscopic images obtained using a 50x magnification for: K material sample – left image; M material sample – middle image; G material sample – right image*

3.2. Roughness testing

Following the laboratory tests of the roughness of the polymer materials using the Insize ISR-C002 roughness meter, different values of the roughness of the three samples were obtained. The value obtained and displayed on the device screen is the roughness value and is expressed in µm. The roughness value of the first tested polymeric K material is 0.629 µm (Figure 9 - left image).

Fig. 8. *Results of the roughness testing: K material sample – left image; M material sample – middle image; G material sample – right image*

The next material tested was the M material. In this case, the numerical value of the roughness is 0.802 µm (Fig. 8 – middle image). The last roughness test was performed on the sample made of the polymeric material G (Fig. 8 – right image). Its numerical value is: 0.434 µm. The three materials have different values, the lowest value belonging to the polymeric material G, followed by the K material and finally by the M material. From these values, it follows that the material with the roughest surface is the M material and the material with the smoothest surface is the G material. We can correlate the results obtained in the microscopic analysis with the results obtained in the case of the roughness analysis. The smoothest material from the point of view of roughness analysis is the material with the most uniform appearance, namely, material G. Considering the purpose of using these materials, we can deduce that the use of a material with a low roughness value, in our case, the G material, is the most desirable from an aesthetic point of view, since it imitates the smooth surface and thinness of the nail plate that requires prosthetics.

3.3. Hardness testing

Following the hardness tests carried out on the samples from the polymer materials, using the Insize ISH-TDV1000A device, the Vickers hardness value was found for each sample. The testing was carried out with preselected values of the apparatus, namely:

N°. 4 - 2023, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2023.4.03

the preset values of the indenter action force, the brightness with which the sample is observed, and the indenter loading time, to find out the Vickers hardness value of materials under equal conditions. For this purpose, a force of 0.5 kg was used, the loading and driving time of the indenter was 10 seconds, and the brightness level was set at 4. The first material tested was the K material, which presented a value of 5 HV (Figure 9 – left image).

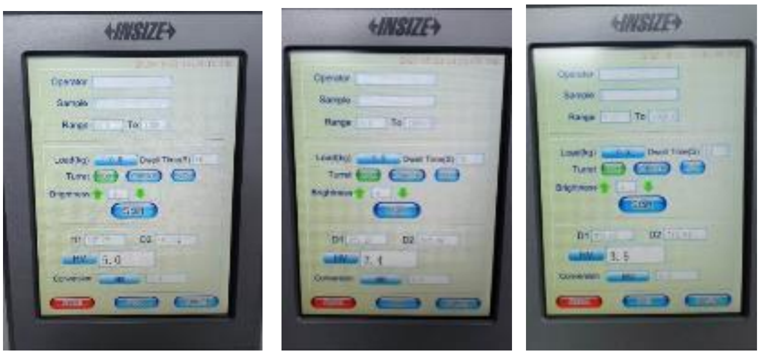

Fig. 9. *Results of the hardness testing: K material sample – left image; M material sample – middle image; G material sample – right image*

The M material was the next one tested, and the recorder value was 2.4 HV (Figure 9 – middle image). The last specimen tested with the durometer was the G material. After testing, the Vickers hardness value was 3.5 HV (Figure 9 – right image). According to these results, in correlation with the purpose of use, we can deduce that the K material has the highest hardness when using these three polymeric materials. The harder the material used in the prosthesis, the greater the resistance of the prosthesis in the event of a shock.

3.4. Mechanical testing

The mechanical testing of the specimens provided an important insight into the mechanical properties of these polymeric materials. For bending strength testing, two specimens of the same material were used, resulting in different curves. The first three-point bending strength test was performed on polymer material K followed by M and G. Based on the data retrieved from the computer linked to the mechanical testing machine, a graph was obtained, with a comparative purpose of the displacement and the force to which all 6 samples were subjected. Based on the graph (Figure 10) a clear difference between the 3 types of materials is observed. The samples from the same material have very similar, almost identical results.

The first material subjected to the bending test was the polymeric material K. According to the graph, the flexural strength of this material from the point of view of displacement was the lowest, managing to yield in the shortest time to the load and break suddenly shortly after the action of 60 N. Also, is the material that recorded the highest withstanding force.

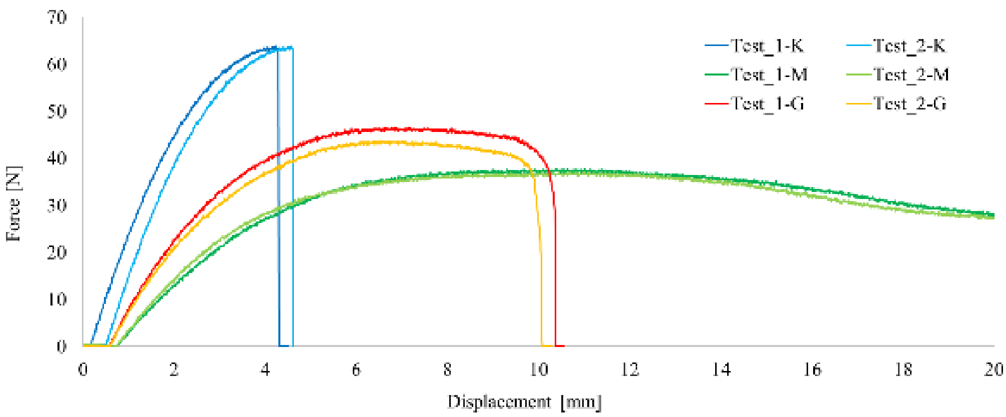

Fig. 10. *Force-displacement diagram for the 3-point flexural bending tests of the K, M and G polymeric materials*

Among all the materials tested, the samples from the polymeric material K were the ones that deformed the least, recording in terms of displacement below 5 mm. In the case of the samples from the polymeric material M, we can observe that samples had the lowest resistance value from the point of view of the applied force, below the value of 40 N, but from the point of view of displacement, they have the highest and most constant strength, without obtaining cracks or breaks on the surface of the samples. After removing the applied force, the polymeric material M samples tended to return to their original shape but stopped before completely do so. Also, no cracks or breakage of these specimens were observed.

The last material tested was the polymeric material G, which, according to the data, is in the middle between the first two, both from the point of view of the displacement and the applied force. The samples of this material cracked on the outside, in a controlled manner, failing to break suddenly as in the case of the polymeric material K. The specimens of polymeric material G had a constant value of the bending strength up to about 45 N, for about 4 mm of displacement, then cracks occurred on the outer side of the specimens, ultimately registering a decrease in the applied force around 10 mm of displacement, without breaking suddenly like the samples from the polymeric material K.

The last material test analysis was compressive strength. For this type of analysis, the compressive strength was measured for two specimens for each material. Using the obtained results, a diagram was plotted with the comparative aim of observing the resistance of each material (Figure 11). The slight variation in height of samples is transposed in different starting points of data curves on the displacement axes.

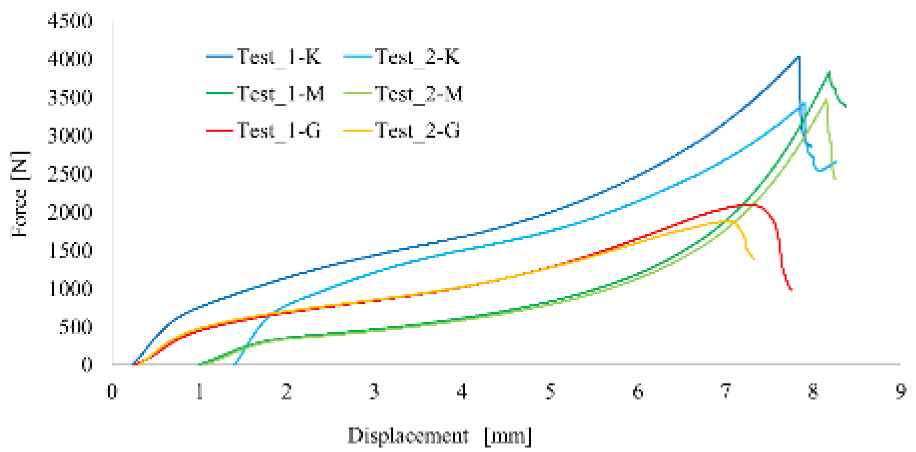

Fig. 11. *Force-displacement diagram for the compressive strength tests of the K, M and G polymeric materials*

The first test was carried out on samples of the polymeric material K. As can be seen from the graph, the samples of this material behaved with a small difference. The first specimen withstood a force of about 4000 N and deformed almost 8 mm. The second sample yielded at about 3000 N of force, and deformed almost 8 mm. Finally, the specimens registered cracks under the action of the upper platen, forming 3 vertical grooves along the specimens that connected each other (Figure 12).

The second material tested was the polymeric material M. In the case of these specimens, the curves of the graph in Figure 11 look similar. Also, the force and displacement values are similar to the ones registered for the previous material. At the end of the test, two long, vertical grooves running through their entire length were observed on each tested specimen (Figure 12).

The last material tested for compression was the polymeric material G. According to the graph, both samples had similar results. They deformed the fastest, under the action of the smallest force, approximately 2000 N, the displacement length a little more than 7 mm. At the end of the test, a short vertical groove was observed on each specimen (Figure 12).

Following the compression tests performed on the three types of materials, the polymeric materials K and M had similar results regarding the maximum withstanding force and displacement even though, the curves emphasize a greater elasticity of the polymeric material M, since it needs lower values of the applied force to obtain the same displacement. The results for the polymeric material G emphasize an elasticity between the other two materials and lower values for the withstanding force and displacement.

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N°. 4 - 2023, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2023.4.03

Fig. 12. *Samples of polymeric materials K – left, M – middle and G – right, after compression strength testing*

Combining the results from the mechanical tests, it can be concluded that between the three polymeric materials, the K and M ones present the most promising results since the data from the compression tests are in their favour with similar values for the force and displacement. The choosing of one against the other can be based on the results from the 3-point flexural bending tests but also on the necessities of the patient, as is the case in the further presented case study.

3.5. Case study for a nail plate prosthesis

The prosthesis of a nail plate with onycholysis resulting from impact was put into practice, using one of the tested materials. Following a trauma, this nail suffered detachment of the nail plate from the nail bed, this problem being known as onycholysis, so that at the time of healing the external trauma, the nail kept this aspect which, with the growth of the nail, will return to normal (Fig. 13).

Fig. 13. *Onycholysis due to external trauma*

Fig. 14. *A healthy nail is presented against the one with onycholysis – left; onycholysis affected nail after prosthetics actions - right*

To provide an accurate picture of the normal condition of this type of nail bed, an image of a healthy nail is presented against the one with onycholysis for comparative purposes in Figure 14. The lack of a portion of the bed and nail plate would have created discomfort for the patient in carrying out physical activities. Figure 14 (right image) also presents the traumatised nail after prosthetics actions.

For the prosthesis of this nail plate the natural nail was brushed to favour the adhesion of the polymer material. After sweeping, it was dusted and degreased and a methacrylate acid solution was applied to maximize the adhesion between the material used and the nail plate [12, 19]. Since the desired appearance was a natural one, it was decided to use the polymeric material M, due to its transparency. A small amount of material was placed on the middle of the nail bed, to be shaped with the help of an applicator soaked in isopropyl alcohol. After placing the material, it was polymerized for 120 seconds in the 36 W ultraviolet light lamp. At the end of the polymerization, the material was degreased and finished to obtain a smooth surface and as similar as possible to the natural nail, both in terms of thickness and aesthetic point of view. As time passes and the natural nail grows, the nail bed will lengthen, allowing the nail to grow where the trauma occurred, and the polymer material can be removed by cutting or filing without affecting the natural nail in any way.

4. Conclusions

The importance of a healthy nail apparatus is supported both by the daily activities to which each person is subjected, whether it is constant protection against environmental factors, whether is about physical activities such as using the fingers, but also by the need for belonging and approval of society. The existence of medical or aesthetic problems leads to a decrease in the self-esteem of individuals, which makes nail prostheses a necessity for the mental health of patients but also for the performance of usual activities without feeling discomfort.

The materials tested in this study were structurally and mechanically compared, providing an overview of the microscopic image of each material, but also exact numerical values when tested for roughness and hardness. These tests are important for understanding the behaviour of the material from which the nail prostheses are made, but also to imitate as much as possible the natural appearance of the nail plates, thus providing a lasting resistance during their use but also a pleasant appearance.

The laboratory tests showed the differences in numerical values and in the case of mechanical analyses of the resistance of polymeric materials to bending and compression, thus providing an image of the physical properties of the K, M and G materials. All these materials can be used to make a nail prosthesis but used for different purposes. According to laboratory tests, the most recommended material from the point of view of bending and compression resistance, hardness and implicitly for all the physical activities that a nail prosthesis involves, is the K polymeric material, because it recorded the highest values to physical tests. On the other hand, due to the colouring pigments, the appearance that this material will provide is not natural or imperceptible.

From an aesthetic point of view, the most recommended material for making a prosthesis for a traumatized or diseased nail plate is the polymeric material M, due to its very natural appearance, but because it recorded the highest value of roughness, the use of this material in prosthesis of a nail plate necessitates grinding and finishing to be as close as possible to a natural nail. From the point of view of physical properties, the polymeric material M is in the middle of the ranking, obtaining numerical values in the bending and compression strength tests in correlation with the force to which they were subjected, lower than the polymeric material K.

The polymeric material G recorded low roughness values, offering the smoothest surface, but due to the silicon dioxide in the chemical composition, it acquires a false aesthetic appearance, inconsistent with the appearance of a natural nail. Also, the values from the mechanical tests ranked it last among all three materials tested, meaning low performances in daily activities.

Thus, it is very important that when constructing a prosthesis for a nail plate, to achieve a balance between the patient's needs and the purpose of the prosthesis, namely: treating the nail plate from an aesthetic point of view as well as its resistance depending on the loads to which it is to be subjected.

References

[1]. Dykyj D., *Anatomy of the nail*, Clin Podiatr Med Surg, 6, p. 215-28, 1989.

[2]. Tosti A., Cameli N., Piraccini B. M., Fanti P. A., Ortonne J. P., *Characterization of nail matrix melanocytes with anti-PEP1, anti-PEP8, TMH-1, and HMB-45 antibodies*, J Am Acad Dermatol, 31, p. 193-196, 1994.

[3]. Ito T., Ito N., Saathoff M., *et al.*, *Immunology of the human nail apparatus: the nail matrix is a site of relative immune privilege*, J Invest Dermatol, 125, p. 1139-48, 2005.

[4]. Walters K. A., Flynn G. L., Marvel J. R., *Physicochemical characterization of the human nail: permeation pattern for water and the homologous alcohols and differences with respect to the stratum corneum*, J Pharm Pharmacol, 35, p. 28-33, 1983.

[5]. de Berker D., *Nail anatomy*, Clin Dermatol, 31, p. 509-515, 2013.

[6]. Fleckman P., *Anatomy and physiology of the nail*, Dermatol Clin, 3, p. 373-381, 1985.

[7]. Rodriguez-Takeuchi S. Y., Villota V., Renjifo M., *Anatomy and pathology of the nail and subungual space: Imaging evaluation of benign lesions*, Clin Imaging, 52, p. 356-364, 2018.

[8]. Adams R. M., *Effects of mechanical trauma on nails*, Am J Ind Med, 8, p. 273-280, 1985.

[9]. Belyayeva E., Gregoriou S., Chalikias J., *et al.*, *The impact of nail disorders on quality of life*, Eur J Dermatol, 23, p. 366-371, 2013.

[10]. Lee D. K., *Optimal diagnosis and management of common nail disorders*, 54, p. 694-712, 2022.

[11]. Iorizzo M., Piraccini B. M., Tosti A., *Nail cosmetics in nail disorders*, J Cosmet Dermatol, 6, p. 53-58, 2007.

[12]. Kanerva L., Lauerma A., Jolanki R., Estlander T., *Methyl acrylate: a new sensitizer in nail lacquer*, Contact Dermatitis, 33, p. 203-204, 1995.

[13]. ***, https://pubchem.ncbi.nlm.nih.gov/compound/4093#section=Structures.

[14]. Kinney S. M., Ortaleza K., Vlahos A. E., Sefton M. V., *Degradable methacrylic acid-based synthetic hydrogel for subcutaneous islet transplantation*, Biomaterials, 281, 2022.

[15]. *, https://astromagazin.ro/microscoape-metalurgice/15202-microscop-metalurgic-inversat-kern-olm-171.html.

[16]. *, Insize ISR-C002, http://www.insize.com/page-169-267.html.

[17]. Tretyakova T., Wildemann V., Tretyakov M., *Investigation of the Portevin-Le Chatelier effect in metals under additional vibration impact by using the DIC-technique and the IR-analysis*, Procedia Structural Integrity, 18, p. 837-842, 2019.

[18]. ***, *Instron 8850*. https://www.directindustry.com/prod/instron/product-18463-1663085.html.

[19]. Kerai L. V., Hilton S., Maugueret M., *et al.*, *UV-curable gels as topical nail medicines: In vivo residence, anti-fungal efficacy and influence of gel components on their properties*, Int J Pharm, 514, p. 244-254, 2016.