How Strong Are Your Fingernails?

By Michael J. Maloney

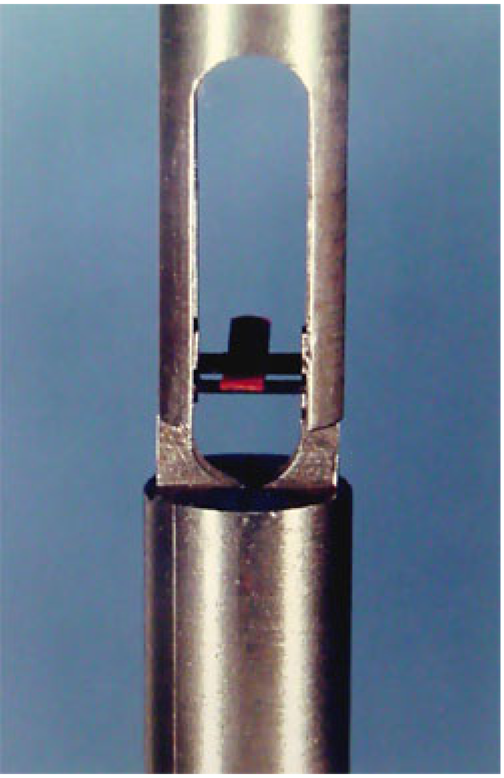
INTRODUCTION

There is remarkably little data on fingernail strength in the recent literature. Bean (1) meticulously studied the growth of his left thumbnail over a period of twenty-five years. His observations regarding the effect of age and a case of the mumps are noteworthy and his philosophy is quite amusing. Caputo and Dadaiti (2) and Jarrett and Spearman (3) made significant contributions to the understanding of nail structure. Donsky (4) and Curtis and Harris (5) developed a method for using sonic velocity as a nondestructive analytical technique for nails. Dixon (6) attempted to evaluate the effect of a commercial nail food on nail splitting. While her results indicated no beneficial effect, she concluded that the trial was an educational success.

Michaelson and Huntsman (7) attempted to provide a numerical answer to the question of whether on not gelatin in the diet has an effect on nail hardness. They used a Knoop indentor to evaluate hardness, and while they concluded gelatin increases hardness, the validity of their data has been questioned by Newman and Young (8). These later authors have proposed that flexural measurements of fingernails should provide the maximum information in the most direct manner (9). Baden also studied nail flexibility and developed two additional methods for measuring modulus of elasticity.

Several years ago, the author and coworkers developed several pieces of apparatus for measuring the physical properties of fingernails (10). The devices are able to measure tensile strength, flexural strength, tearing strength, and impact absorption characteristics of nails. The author (in collaboration with Paquette and Shansky)(11) also adapted a device developed by Gusman (12) to the measurement of internal stress in nail lacquers. Since that time, the author has performed numerous tests aimed at measuring the effect of different materials (e.g. solvents, detergents, nail polishes, and nail “strengthening” treatments) on nails.

Having independently arrived at the same conclusion as Baden, Newman, and Young, and having designed and built an apparatus for measuring flexural strength, the author supports their conclusions regarding the value of flexural data. A particular advantage of flexural strength measurement is that it has been demonstrated to be nondestructive. This feature, which allows the same nail sample to be tested over and over, is invaluable for experiments where it is desired to determine the effect of exposure to various



environments. Also, since each nail sample can serve as its own control, the number of experiments necessary to achieve statistical significance is greatly reduced.

DESCRIPTION OF THE FLEXURAL STRENGTH TEST APPARATUS

The procedure for determining the flexural properties of plastics is described in ASTM method D 790 (13). The specifications call for a specimen, in the form of a rectangular bar, which is positioned on 2 supports with a load applied to the midpoint of the span.

The apparatus normally used for flexural strength tests is far too large to accommodate fingernails. To overcome this problem, therefore, a miniature fixture (Figure 1), to be used in conjunction with a suitable testing apparatus (e.g. an Instron tester) was designed and fabricated. Even though the apparatus is much smaller than what is normally used, the ratio of sample thickness to support radii is not changed, and the standard interpretive formulae may be employed.

TEST SPECIMEN PREPARATION

Fingernail samples are rinsed with reagent-grade acetone to remove nail polish residues and other foreign substances. They are then soaked in distilled water until they are sufficiently flexible to facilitate flattening and cutting.

Test specimens are cut from the nails by placing the nail on two razor blades that are mounted 0.1” apart in a fixture and then applying pressure to the top surface of the nail until the test specimen is removed. Two adjacent specimens are taken from each nail. The specimens are cut perpendicular to the fiber axis of the nail, (a procedure that is in keeping with Badens’ (14) conclusion that small, if any, difference in physical properties is found between samples cut perpendicular or parallel to the fiber axis.) Since previous researchers have noted large differences in nail properties that can be attributed to variations in humidity, the nail samples are conditioned at least 24 hours, at 65% relative humidity, prior to testing.

FLEXURAL TESTING EXPERIMENTS

Pre-conditioned nail samples are positioned in the test fixture and then subjected to a total deflection of 0.02”, at a crosshead speed of 0.05”/minute. The testing apparatus is calibrated to measure forces in the range of 0 to 2 pounds. In our initial experiments, tangent modulus of elasticity, stress at a given strain, and flexural yield strength were calculated for each specimen. Ultimately, however, we determined that the flexural yield strength values are the most representative and since that time, we have only determined that value.

CADAVER NAILS vs. NAILS FROM LIVING SUBJECTS

An important consideration in our fingernail strength experiments was how to obtain a sufficient quantity of nail samples to allow us to reach statistically significant conclusions. Cadaver nails are an attractive option for several reasons: 1. they are larger (entire nails vs. clippings) which allow us to obtain more samples from each nail 2. full length nails allow the test specimens to be cut parallel to the fiber axis, and 3. it is frequently possible to obtain an entire set of nails (10 samples) from a single donor, whereas living donors seldom have that many nails that are long enough to provide usable samples.

An experiment was performed to determine if there is a significant difference in the strength or physical characteristics of nails from cadavers and nails from living donor's. Nine specimens were obtained from living, female donor's, between the age of 14 and 26 and nine similar specimens were obtained from the nails of female cadavers that ranged in age from 38 to 62 at the time of their death. After the nails had been cleaned, soaked, flattened, and cut, there were no visible differences in the appearance of the two types of nails. The specimens were tested to determine their flexural strength and then reconditioned for 24 hours @ 65% relative humidity and retested. The procedure was then repeated on 5 consecutive days. The test results showed that there is no significant difference in the initial strength of the nails or their ability to withstand repetitive testing.

AN INITIAL NAIL STRENGHT EXPERIMENT

Shortly after the fingernail flexural strength apparatus was completed, an experiment was performed to gain experience with the test procedures and to obtain baseline information for future studies. Fingernails from the first and third digits of both hands from 8 human cadavers (4 females and 4 males), age at death between 53 years and 98 years, were selected for the initial study (Table 1).

- **Table 1**

Sex	Age at Time of Death
Male	58
Female	53
Male	66
Female	68
Male	75
Female	74
Male	98
Female	93

TEST RESULTS

DIFFERENCES ATTRIBUTABLE TO AGE

We anticipated that our tests would show a decline in nail strength with increasing age. Bean (1) and Sammon (15) have reported a gradual slowing of nail growth associated with increasing age. Lewis and Montgomery (16) described senile changes in nail appearance, dullness, opacity, and alteration of the nail plate thickness, longitudinal ridging, and marking of the luna.

The results of this study indicate, however, that age is not a significant factor in predicting nail strength or resiliency. Like Lewin (17) who found that the senile changes reported by Lewis and Montgomery also appeared in the younger age groups, we found that nail strength appears to be independent of age. (The nails of the oldest donor (98 years) have an average flexural strength of 11,116 psi, which is close to the average value for the study population.

Although the study showed no significant differences attributable to age, it should be kept in mind that the values represent only a single age for each individual. The question of whether the properties of nails change during an individual's lifetime was not addressed and would provide the basis for an interesting long-term study.

DIFFERENCES ATTRIBUTABLE TO SEX

The results of our study indicate a statistically significant difference in nail strength which can be attributed to the donor's sex. The average flexural strength of the female donor's nails were significantly higher than their male counterparts. Although Newman, Young, and Capott (9) did not mention sex-related differences among their findings, it is apparent that the nails of the female donor's in their study also had a higher flexural strength than those of the males.

DIFFERENCES ATTRIBUTED TO HAND OF NAIL ORGIN

When the data were analyzed as a whole, we found no significant difference in nail strength which could be attributed to hand of origin. When the data from each donor were analyzed individually, however, we found a significant difference. The right hand nails had the highest strength for the majority of the donor's and, because most individuals are right handed, it appears likely that the hand of preference develops superior strength nails.

GENERAL OBSERVATIONS

The author has conducted hundreds of tests, over a 40 year period, for the purpose of determining the effect of various materials on the strength of fingernails. Some of the observations that resulted from the tests were at least a little surprising. It is generally believed, for example, that prolonged immersion in water is damaging to nails. One of the most important findings that resulted from our testing is that water is the “great healer” of fingernails.

During our investigations, we have exposed fingernails to many materials (e.g. solvents like acetone, and carbon tetrachloride) that make the nails temporarily very “hard” and brittle. When the nails are subsequently re-hydrated by immersion in water, however, they quickly revert to the same strength and flexibility that they had before they were exposed to the solvents.

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About the author: Michael Maloney is the President of Bjorksten Research Laboratories and has over 40 years of experience in research, development, and testing. He holds patents in several areas and has published other articles on testing and the development of testing devices. He began testing fingernails over 35 years ago, in conjunction with a

research program sponsored by Del Laboratories, Inc., and continues to study the interesting topic of fingernail strength whenever an opportunity presents itself.