The History of Plastination in China

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Abstract:

Plastination was introduced in the Chinese province of Jiang Su in 1997. This paper describes the modifications that had to be made to the standard plastination technique to make it accessible to Chinese education institutions and to fulfill the enormous needs for plastinated specimens that were identified in China. In order to reduce the cost, the standard protocol had to be modified. The equipment and polymers also had to be produced locally. This paper also demonstrates that plastination can be made possible for developing countries.

Introduction

In June 1997, Dr Zheng returned to China after having worked in plastination laboratories in Iceland (1991-1995) and Hong Kong (1995-1997). During these years of work and research, a direct reading acetonometer was developed (Zheng, 1995) and various adaptations were made to the standard impregnation process (Zheng and al., 1996). The enormous needs for plastinated specimens in various levels of Chinese education institutions were easily identified but the cost of importing the equipment and polymers rendered plastination on a large scale impossible in China. A project was then elaborated in collaboration with the Ministry of Education of the Jiang Su province in order to identify all the essential equipment and research was started to produce these locally in order to reduce cost. The standard silicone impregnation procedure developed by von Hagens (1985) required low temperatures. However, plastination at room temperature (Zheng et al., 1996; 1998a) was adopted in order to avoid the cost of buying freezers. After six months of research a Chinese silicone was developed. Using this silicone and the modifications for room temperature, the Nanjing Plastination Factory (figure 1) produced a few thousands of specimens since its inception in 1997. These specimens are now widely used in many Chinese schools and universities. The development of these new, less expensive techniques for plastination have since allowed plastination laboratories to open in some Chinese universities.

Equipment and Process

All the equipment (vacuum chambers, vacuum pumps, etc.) used in our laboratory was fabricated in China thus eliminating the cost of importation. The standard plastination procedures described by von Hagens (1985) require freezers for the dehydration and impregnation steps to be performed at low temperature. To render the process secure, explosion-proof or modified freezers have been recommended (Gubbins, 1990; Baptista et al., 1992).

Room temperature dehydration

To avoid the explosion hazard and to reduce cost, room temperature dehydration in increasing grades of ethanol has been previously described (Kularbkaewc et al., 1996) but resulted in excessive shrinkage as compared to the recommended freeze substitution method (Schwab and von Hagens, 1981). The specimens dehydrated in the grades of ethanol also had to be placed in 2 baths of acetone for a total time of one month as ethanol can not act as the intermediary solvent.

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Figure 1. Main building of the Nanjing Plastination Factory.

For these reasons, we have developed a room temperature dehydration process (Zheng et al., 1996; 1998a) in a graded series of acetone solutions that gives very satisfactory results. It is important to note that for some tissues (i.e. brain) shrinkage may be marginally increased with room temperature dehydration as compared to the freeze substitution method. However, for new plastination laboratories with limited resources it is important that the room temperature process reduces considerably the cost as we do not need any freezer.

Room temperature impregnation

The standard method also recommend the use of the Biodur™ silicone mixture (S1O/S3) at -20°C and its storage at -70°C (Biodur, 1994). Some S10 room temperature impregnation procedures have nevertheless been reported (Ripani et al., 1994; Kularbkaewc et al., 1996, Zheng at al., 1996). Further, most of the plastination laboratories store their silicone at -20°C (Henry and Nel, 1993).

Immersion of the specimens to be plastinated in the silicone bath before starting the forced impregnation has been previously recommended for a period of one day (Henry and Nel, 1993) to as long as one week for brains (Weiglein, 1996). This immersion period allows the surface solvent and the polymer reaction mixture to equilibrate. It has also been stated that longer immersion will result in shorter impregnation time (Weiglein, 1996). This demonstrates that an exchange between the silicone and the acetone contained within the specimen is happening without vacuum. Immersion after the completion of the impregnation is also recommended (Henry and Nel, 1993) to allow the polymer in the specimen to equilibrate with the impregnation bath.

Starting with these principles, we elaborated what we refer to as the "three steps impregnation". The principle is simple. First, the specimens are submerged for 5 to 7 days in the silicone bath. The surface impregnation of the specimens starts during this period. Subsequently, an "intermittent forced impregnation" procedure is begun. The vacuum pump is activated during the day and atmospheric pressure reestablished into the impregnation chamber during the night. This step lasts 12 to 20 days depending on the size of the specimens to be impregnated. This series of alterning vacuum and ambient pressure applied may cause less stress to the specimens and, as a result, appears to reduce the shrinkage. The third and final step is simply a period of 3 to 4 days in which the specimens are kept in the silicone mixture at atmospheric pressure.

The vacuum pump is running during 12 to 20 days, 8 hours per day, compared to the traditional 3 - 5 weeks, 24 hours per day. The reduced total hours of utilization (96 -

160 hours compared to 500 - 840 hours) would be expected to enhance the life time of the pump. This procedure allowed us to use less expensive pumps and to plastinate thousands of specimens since 1997 without major damages to our pumps.

Polymers

The standard Biodur™ silicone S10 can be kept for a very long time at room temperature but following mixing with its hardener S3 it must be used and stored in a freezer (Biodur, 1994). Use and storage of the mixture at room temperature will lead to a fast thickening of the mixture that will render it useless after a certain time. Because of these characteristics, we needed to develop a silicone that could be stored for a long period of time and used at room temperature. After six months of work, our research group developed a new silicone suitable for plastination. It can be used and stored at room temperature for years without increasing it's viscosity. We named it the Su Yi Chinese silicone.

The viscosity at room temperature (10 to 25°C) of the Su Yi Chinese silicone is about 200 mPa compared to the Biodur S10 silicone that is 500 mPa at 20°C (Biodur, 1989). This difference makes the penetration ability of the Su Yi silicone easier and faster. The exchange between acetone and silicone in absence of vacuum is also enhanced, which permits a better impregnation with reduced shrinkage using the intermittent vacuum process.

Results

Within three years, we have been able to develop equipment and polymers that made plastination on a large scale possible in China. Many thousands of specimens ranging from small animals (figures 2 - 6) to whole human bodies (Zheng et al., 1998b) have been produced using our techniques and polymers and are now used in 20 Chinese schools and universities. The specimens have retained their original shape and colors. The average shrinkage observed is around 5%.

Two different types of plastinated specimens are produced with the Su Yi Chinese silicone, dry and rigid or soft and oily. The complete curing reduces considerably the flexibility of the thick plastinated specimens even if flexible thin specimens can be produced (von Hagens, 1979). The production of thicker flexible specimens have also been described (Henry and Butler, 1990) using the "incomplete impregnation method". To date we have to make a choice between a dry but hard specimen or a soft but oily specimen. Our research continues in order to improve our silicone and plastination technology to produce the ideal type of soft plastinated specimens with dry surfaces.

Discussion

China is a big country divided in 32 provinces and areas. It's population of 1,250,000,000 people includes about 240,000,000 students in school of various levels. Many of these study animal and human biology. Each year more than 70,000 new medical students make their entry in the 1,000 Medical Universities and Schools and therefore start to study human anatomy. These data provide a rough estimate of the enormous needs of biological specimens to assure a good education to all these students.

Due to the safety concerns about the utilization of formaldehyde in biology and anatomy classes, the ministry of education wishes to minimize utilization of this chemical for the health of teachers as well as students. This creates an immense demand for plastinated specimens and millions of these will have to be produced to fulfill our needs. Because of the cost involved, importation of such a great number of teaching specimens is impossible, so the need for local production is obvious.

Another safety concern is the enormous amount of acetone required to dehydrate so many specimens. This also represents an important part of the plastination cost. Since various methods have been described before to recycle acetone (Smith, 1990; Roark, 1991; 1993; Grondin and Berube, 1992; Janick and Henry, 1995; Grondin et al., 1997), our research group at the Nanjing Plastination Factory also developed a very efficient acetone distillation apparatus (Zheng et al., 1998b).

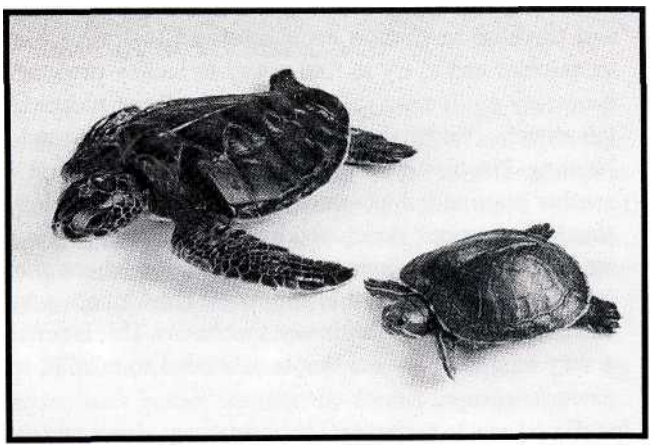
The first plastination laboratory was created in Canton in 1996. At this time, Dr. Zheng was working in Hong Kong and traveled to Canton each weekend to train Chinese technicians and to try to find a way to locally produce the necessary equipment. Since that time, three plastination laboratories (in Shanghai, Beijing and Canton) and the Nanjing Plastination Factory have developed. In 1998, another plastination laboratory opened in Dalian using the standard technique developed by Dr. von Hagens. We will continue to work to create more plastination laboratories in other areas of China and to supply all the Chinese schools and universities with plastinated specimens. This is certainly a very long term project that is estimated to take 20 to 30 years.

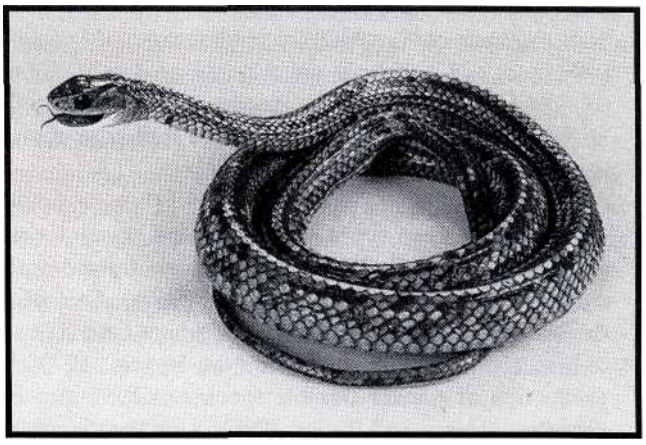
We finally hope that our experience will serve as an example for other developing countries and promote plastination to as many countries as possible.

Bibliography

Baptista CAC, Bellm P, Plagge MS, Valigosky M: The use of explosion proof freezers in plastination: Are they really necessary? J Int Soc Plastination 6 (1): 34-37, 1992. Biodur Company: DIN Safety Data Sheet. Commercial product name: BIODUR S 10. Heidelberg, Germany, p 1, 1989. Biodur Company: Biodur™ Products, Polymers, Auxiliaries, and Equipment for Plastination, Catalog & Price List. Heidelberg, Germany, p 35, 1994. Grondin G, BeYube S: A simple and inexpensive method for recycling used acetone in plastination laboratories. J Int Soc Plastination 6 (1): 17-19, 1992. Grondin G, Henry RW, Janick L, Berube S: Reclamation of Acetone in Plastination Laboratories: A Simple and Inexpensive Method. ActaAnat 158 (1): 26-29, 1997. Gubbins RBG: Design of a plastination Laboratory. J Int Soc Plastination 4 (1): 24-27, 1990. Henry RW, Butler J: Room-temperature "forced air" impregnation of dried lungs with S10/S3-xylene mix. J Int Soc Plastination 4 (1): 14-15 and 23, 1990. Henry RW, Nel PPC: Forced impregnation for the standard S10 method. J Int Soc Plastination 7 (1): 27-31, 1993. Janick L, Henry RW: Reclamation of acetone by freeze vacuum distillation. J Int Soc Plastination 9 (1): 27-30, 1995. Kularbkaewc C, Cook P, von Hagens G: Plastinated pathology specimens at room temperature in Thailand. J Int Soc Plastination 11 (1): 17-20, 1996. Ripani M, Bassi A, Perracchio L, Panebianco V, Perez M, Boccia ML, Marinozzi G: Monitoring and enhancement of fixation, dehydration, forced impregnation and cure in the standard S-10 technique. J Int Soc Plastination 8 (1): 3-5, 1994.

Roark RR: High purity solvent recycling of acetone in the plastination laboratory. 2nd Interim Conf Plast, Rancho Cucamonga, CA, USA, 1991. Abstract in J Int Soc Plastination 6 (1): 6,1992. Roark RR: Reclamation of acetone/solvents. Distillation demonstration. 3rd Interim Conf Plast, Mobile, AL, USA, 1993. Schwab K, von Hagens G: Freeze substitution of macroscopic specimens for plastination. Acta Anat **111:** 139-140, 1981. Smith M: Time and money savers in S10-technique. Acetone distillation. 5th Int Conf Plast, Heidelberg, Germany, 1990. Abstract in J Int Soc Plastination 4 (1): 13, 1990. von Hagens G: Impregnation of Soft Biological Specimens with Thermosetting Resins and Elastomers. Anat Rec 194 (2): 247-255, 1979. von Hagens G: Heidelberg Plastination Folder. Anatomisches Institut, Universitat Heidelberg, Heidelberg, Germany, 1985. Weiglein A: Preparing and using S-10 and P-35 brain slices. J Int Soc Plastination 10 (1): 22-25, 1996. Zheng TZ: The acetone gas detector for plastination. 7th Int Conf Plast, Graz, Austria, 1994. Abstract in J Int Soc Plastination 9 (1): 25, 1995. Zheng TZ, Weatherhead B, Gosling J: Plastination at room temperature. J Int Soc Plastination 11 (1): 33, 1996. Zheng TZ, Jingren L, Kenning Z: Plastination at Room Temperature. J Int Soc Plastination 13 (2): 21-25,1998a. Zheng TZ, Xuegui Y, Jingren L, Kerming Z: A Study on the Preservation of Exhumed Mummies by Plastination. J Int Soc Plastination 13 (1): 20-22, 1998b.





Figures 2 and 3. Sea turtles and snake plastinated with the Su Yi Chinese silicone.

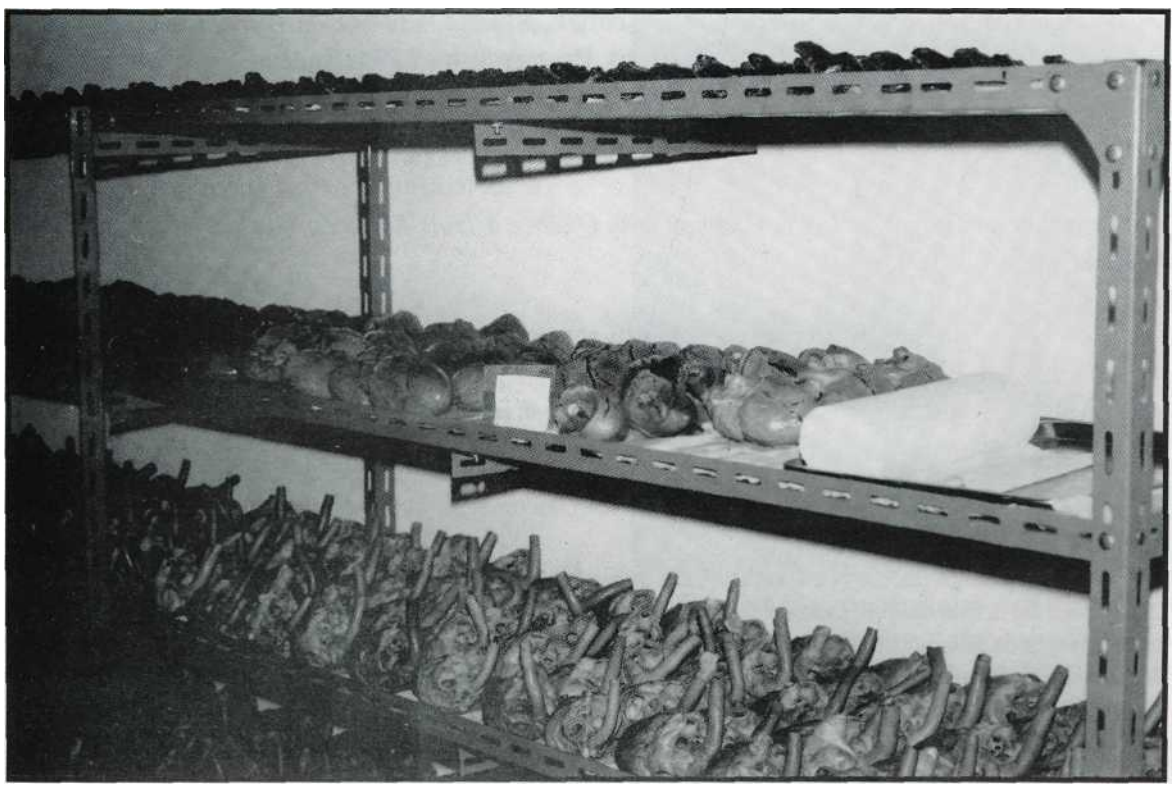


Figure 4. Plastinated specimens within the curing room. Pig hearts and frogs (top shelf).

Figures 5 and 6: Lizard and fish plastinated with the Su Yi Chinese silicone.