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A Custom-made Drying Rack for Precision Microsurgical Instruments: Design and Clinical Application

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ABSTRACT: Objective This study aims to design and fabricate a custom drying rack for precision microsurgical instruments and to evaluate its clinical effectiveness. **Methods** A total of 680 precision microsurgical instruments, manually cleaned between January and February 2025, constituted the control group, and 660 instruments manually cleaned between March and April 2025 constituted the experimental group. The control group underwent drying using conventional methods, while the experimental group was dried using the custom-made drying rack for precision microsurgical instruments. **Results** The drying pass rates for the control and experimental groups were 73.82% and 91.97%, and the drying times were 1 081.47±15.36 s and 568.69±13.75 s, respectively. Between-group comparisons demonstrated statistically significant differences ($P<0.05$). **Conclusion** The custom-made drying rack for precision microsurgical instruments effectively shortens the drying time, improves drying efficacy, and accelerates the turnover of surgical instruments.

KEY WORDS: Precision microsurgical instruments; Drying rack; Design; Application

Introduction

With the continuous advancement of surgical technology, an increasing number of precision instruments are being used in operations, which poses greater challenges for the management of such instruments in central sterile supply departments[1]. As a type of precision instrument, microsurgical instruments are characterized by their small size, complex structure, and specialized materials[2]. According to relevant specifications, protective measures should be taken for precision instruments[3]. In practice, medical institutions often use silicone pads to protect these instruments. However, the difficulty in drying silicone pads leads to excessively long drying times for instruments, thereby prolonging their overall turnover time. To address this issue, our team developed a custom-made drying rack for precision microsurgical instruments (patent No. ZL20242079 5943.7) and evaluated its practical application effect, as reported below.

1 Subjects and Methods

1.1 Study Subjects

A total of 680 microsurgical instruments collected centrally from January to February 2025 were randomly selected as the control group, including 414 ophthalmic microsurgical instruments and 266 neurosurgical, hand, and foot microsurgical instruments. A total of 660 microsurgical instruments collected centrally from March to April 2025 were selected as the experimental group, including 398 ophthalmic microsurgical instruments and 262 neurosurgical, hand, and foot microsurgical instruments. The types and quantities of instruments did not differ significantly between the two groups ($P>0.05$).

1.2 Methods

1.2.1 Design of the drying rack

The custom-made drying rack for precision microsurgical instruments consists of a silicone pad, a drying tray, and a drying support. The drying support is inclined at an angle of 30°~45° and is placed inside the bottom of the drying tray. The drying

support comprises L-shaped inclined rods, support rods, a first fixing rod, and a second fixing rod. At least two L-shaped inclined rods are perpendicular to the bottom surface of the drying tray, with their ends fitting flush against the bottom surface. The support rods are perpendicular to the L-shaped inclined rods, with their ends connected to the L-shaped inclined rods, thereby forming an inclined surface. One end of each L-shaped inclined rod is connected to the first fixing rod, and the other end is connected to the second fixing rod. The first and second fixing rods are parallel to the support rods. The silicone pad has multiple holes and raised bumps on its outer surface, which improve drying efficiency while protecting the precision surgical instruments from falling. In addition, the drying tray is equipped with symmetrically placed hanging lugs on the inside and a handle on the outside for convenient handling and removal. A structural diagram is shown in Figure 1-A.

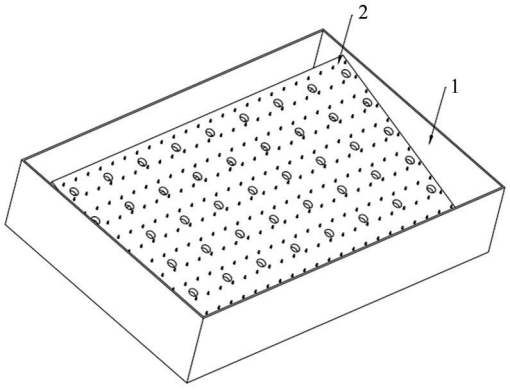


Figure 1-A: Overall View of the Drying Rack

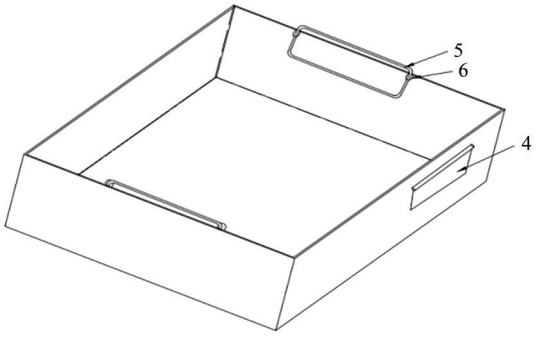


Figure 1-B: Drying tray of the Drying Rack

1.2.2 Grouping and treatment

1.2.2.1 Same cleaning method for both groups

Precision microsurgical instruments in both groups were cleaned manually. A decontamination area nurse classified and counted the instruments. First, a moisturizing agent was sprayed onto bloody microsurgical instruments to prevent the blood from drying. The instruments were then arranged neatly in a dedicated instrument box, with joints opened as far as possible, and rinsed under running water. Subsequently, the instruments were soaked in an enzymatic solution for 2~3 minutes; ophthalmic instruments were cleaned using a detergent without surfactants. After soaking, all parts of the instruments were rinsed under running water, followed by a final rinse with purified water. Finally, the instrument surfaces were wiped with a low-lint cloth.

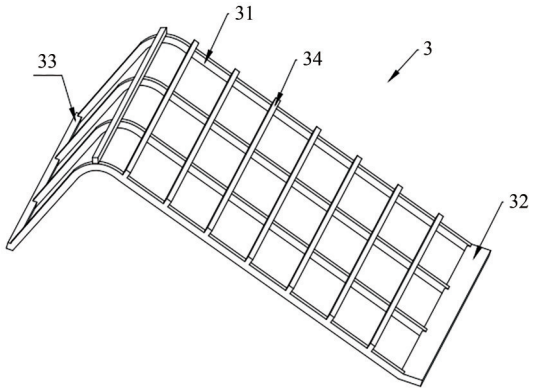


Figure 1-C: Drying support of the Drying Rack

Note: 1. Drying tray; 2. Silicone pad; 3. Drying support; 4. Handle; 5. Hanging lug; 6. Fixing piece; 31. L-shaped inclined rod; 32. First fixing rod; 33. Second fixing rod; 34. Support rod.

1.2.2.2 Drying methods of the two groups

Control group: The cleaned precision instruments were placed in a dedicated instrument box lined with a silicone pad, sprayed with 75% alcohol for disinfection, and then transferred horizontally to a hot air-drying cabinet. The drying temperature for metal instruments was set to 70℃~90℃.

Experimental group: The cleaned precision instruments were properly secured on the precision microsurgical drying rack, which was equipped with a silicone pad for protection and fixation. The drying rack was then placed in a hot air-drying cabinet. Water droplets rapidly slid down along the inclined angle and through the multiple holes into the water collection box.

1.3 Evaluation methods

This study used an indicator-based evaluation

to compare the drying pass rate and the average drying time of instruments between the two groups. (1) Drying pass rate within the same time period. The drying effect was assessed after the hot air drying cabinet had been in operation for 15 minutes. Instrument surfaces were inspected under natural light and with a 10× magnifying glass; the absence of visible water droplets indicated a pass. For lumens, a compressed air gun was used to blow air into one end, and a piece of white gauze was placed at the opposite end; the absence of water stains or moisture on the white gauze indicated that the lumen was dry[4]. The drying pass rate was calculated as the number of instruments that passed drying divided by the total number of instruments. (2) Average drying time of instruments. This was defined as the average time required from the start of drying until the drying standard was met after cleaning, expressed in seconds and using a single set of instruments as the statistical unit.

1.4 Statistical analysis

SPSS 22.0 was used for statistical analysis. Categorical data were reported as frequencies and percentages, and continuous data were reported as mean ± standard deviation (SD). The chi-square test was used to compare drying pass rates between the two groups, and the t-test was used to compare average drying times. A P value of <0.05 was considered statistically significant.

2 Results

2.1 Drying pass rate of precision instruments

The drying pass rate was 73.82% in the control group and 91.97% in the experimental group, representing a statistically significant difference (P<0.05), as shown in Table 1.

2.2 Average drying time of precision instruments

The results showed that the average drying time of the control group was 1 081.47±15.36 s, compared to 568.69±13.75 s for the experimental group. The difference between the two groups was statistically significant (P<0.001), as shown in Table 2.

3 Discussion

Industry standards[5] and guidelines[6] mandate thorough drying of instruments. The degree of drying is crucial for preventing bacterial regrowth and ensuring successful sterilization[7]. Residual moisture not only causes rust and shortens instrument life but also promotes biofilm formation, increases cleaning difficulty, interferes with sterilant penetration, and compromises the quality of sterile items. Most research on drying methods has targeted instruments with special structures. For lumen instruments processed in automatic washer-disinfectors, extending the drying time and performing targeted drying on special structural parts are recommended[8]. Currently, central sterile supply departments commonly combine multiple drying techniques for precision instruments, such as compressed air guns, 95% alcohol spraying or perfusion, low-lint cloths, and low-temperature vacuum drying cabinets[9], consistent with other reports[10-12]. In contrast, research on precision microsurgical instruments has predominantly focused on packaging and sterilization[13], while studies on their drying methods are comparatively rare.

Owing to the special structure of precision microsurgical instruments, manual cleaning is predominantly used in practice. These instruments are placed

Table 1 Comparison of drying pass rates of instruments between the two groups

Group	Number of instruments	Number passed drying	Pass rate (%)	χ^2 value	P value
Control group	680	502	73. 82	77. 3	<0. 001
Experimental group	660	607	91. 97		

Table 2 Comparison of average drying times of instruments between the two groups

Group	Number of instrument sets	Drying time (s, mean ± SD)	t value	P value
Control group	34	1 081. 47±15. 36	24. 82	<0. 001
Experimental group	33	568. 69±13. 75		

SD: standard deviation.

in dedicated instrument boxes with silicone pads for protection, and drying is carried out within the same boxes. However, because the instruments cannot be fully opened at the joints, the silicone pad is difficult to dry, and the water permeability of the instrument box is limited. Consequently, the drying time of the instruments becomes excessively long, which is an important factor affecting instrument turnover. Moreover, given the high cost of such instruments, hospitals have a relatively insufficient supply, while the clinical demand for faster instrument turnover continues to increase.

Based on the structural characteristics of precision microsurgical instruments, this study designed and developed a dedicated drying rack. Its safe inclined angle facilitates the downward flow of water droplets, while the surrounding and bottom protection ensures instrument safety. In addition, the drainage holes at the bottom effectively shorten the drying time and improve drying efficiency, supporting the clinical applicability of this device. However, given the relatively simple experimental method used in this study, future research may incorporate additional indicators to evaluate drying effectiveness. Moreover, the impact of this design on the failure rate of low-temperature hydrogen peroxide sterilization warrants further investigation.

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