

Longevity of Laser Welded Space Maintainers: A Retrospective Cohort Study

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Abstract:

Background: laser welding is proposed to be a safe efficient alternative to silver soldering in the fabrication of space maintainers. **Aim of the study:** Evaluation of the longevity of laser welded space maintainers. **Subjects and Methods:** Eligible records of 163 patients with newly fitted 236 laser welded space maintainers, provided in Minia University Dental Hospital, Minia City, Egypt, were selected to investigate the longevity of the appliances for 2 years of function or till removal as they accomplished the original purpose of fitting. Data were extracted from patients' clinical records by 2 independent investigators. **Results:** Fracture at the band and wire joint was not detected in all space maintainers since their provision till the end of the follow-up (100% success rate). 127 space maintainers were removed as accomplished their purpose and 109 were still in function. **Conclusion:** Laser welded space maintainers exhibit higher clinical performance than silver-soldered ones.

Clinical relevance: The safer laser welded SMs provide a superior alternative to conventional silver soldered.

Keywords: laser welded, silver soldered, space maintenance.

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Introduction:

Despite the advances in preventive dentistry, premature loss of primary teeth still constitutes a problem affecting the integrity of the dental arch and the proper alignment of permanent successors. These adverse effects can be eliminated or reduced by the immediate provision of space maintainers (SMs).^[1]

Soldering and welding are used for joining bands and wires of pediatric dental appliances. Soldering involves joining parent metals together with different metals at a temperature exceeding 450°C. While in welding, parent metal melts and then solidifies to achieve fusion. Traditional silver soldering is more common in practice than laser welding since it is less costly, does not require specific machines and technicians are more trained in its use^[2].

However, a disadvantage of soldered SMs is the failure of these appliances at the solder joint^[3]. Soldered SMs are subjected to corrosion releasing toxic metallic ions. Cytotoxicity tests using cell cultures confirmed the toxic effects of silver soldering on mucosal cells^[4]. Recently, laser welded dental appliances

have begun to be used. Focused laser welding is proposed to be a safe efficient alternative to silver soldering^[5]. Therefore, the current study was conducted to clinically evaluate the durability of laser welded SMs.

Methods:

The current retrospective cohort study investigated the longevity of newly fitted laser-welded SMs through patients' records. The study was approved by the Ethical Committee of the Faculty of Dentistry, Minia University (reference no. 840/2023). The study followed the guidelines for strengthening the reporting of observational studies in epidemiology (STROBE).

SMs were provided in Minia University Dental Hospital (MUDH) in Minia City, Egypt between February 2021 and January 2022. SM lifetime and problems encountered were assessed for 2 years after fitting or till removal either as they accomplished the original purpose or showed breakage at the wire and band joint. The study's endpoint was the 1st of February 2024.

Eligibility criteria

A. Inclusion criteria

- Patients' records with adequate pretreatment assessment before provision of SM.
- Patients with no relevant medical history
- Patients having a lingual arch, Nance appliance, band and loop, crown and loop, transpalatal arch, and modified fixed partial denture; also leeway space holding appliances with or without primary tooth extraction.
- All SMs evaluated were newly constructed. They were made by the same laboratory using orthodontic round stainless steel wire welded to molar bands.
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- SMs that exhibited other modes of failures rather than fracture of band and wire joint except for cement loss if the SM was refitted within days.

Information retrieved from patients' records

Details of the patient's date of birth, and data concerning the type of SM, fitting date, progress, and fate of each appliance were extracted from patients' clinical records by 2 independent investigators and were assessed in February 2024.

Criteria for evaluation of success and failure of space maintainers:

Each appliance was considered successful if the record revealed that the SM lasted for 2 years or functioned well till removal as it accomplished the original purpose of its fitting. An appliance was considered a failure if the patient's records demonstrated that the joint between the band and wire was fractured, even if it was no longer needed.

Retrieved data were entered into an Excel spread sheet for Subsequent analyses using the Statistical Package for the Social Sciences software (version 26, SPSS, Chicago, Ill) for Windows 10 to determine the longevity of the appliances.

B. Exclusion criteria

- Patients who had received dental treatment from another dental service during the study period.
- Patients with incomplete records or those who lost follow-up.
- Patients with active appliances involving tooth movement.
- SMs that were recementation or repair, and those that were replacements of the original ones.

Quantitative data were presented by mean and standard deviation.

Results:

The clinical records of patients with newly constructed SMs fitted between February 2021 and January 2022, were originally identified. Records of 163 patients with 236 laser welded SMs met

the eligibility criteria and were enrolled. The patient ages ranged between 3.7 to 10.5 years, with a mean age of 6.98 ± 5.03). They were 104 females and 59 males (Figure: 1). The SMs enrolled in the study were 152 band and loop, 14 crown and loop, 25 Nance, 37 Passive lingual arch, 2 Transpalatal arch, and 6 modified fixed partial dentures (Table: 1).

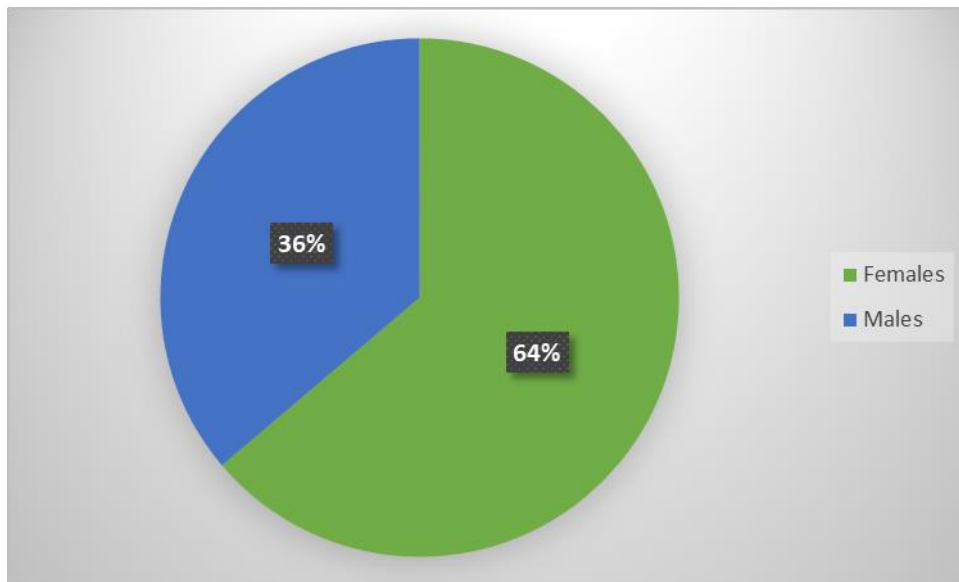
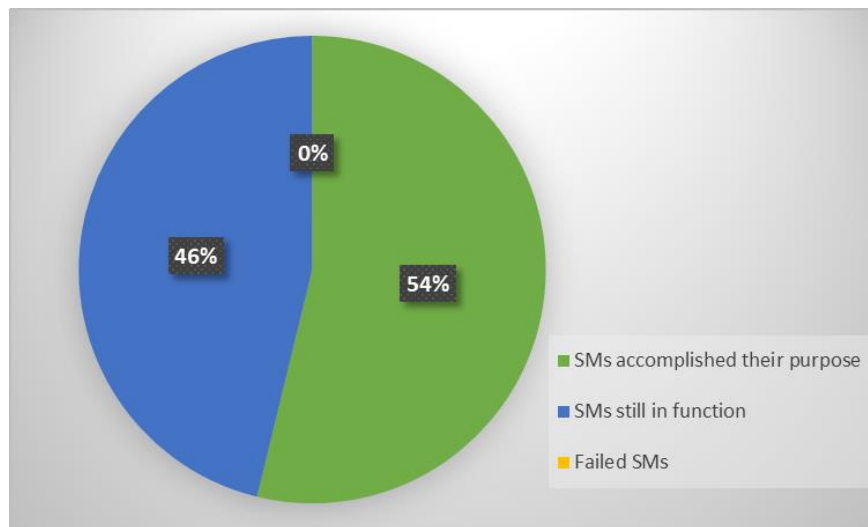


Figure (1): Distribution of the male and female patients included in the study.

Table (1): The different types of SMs included in the study.

Type of SMs	Number	Percentage	Age Range (years)
Band and loop	152	64.41%	3.9 to 9.1
Crown and loop	14	5.93%	4.4 to 7.3
Nance appliances	25	10.95%	7.2 to 10.5
Passive lingual arch	37	15.68%	8.1 to 10.3
Transpalatal arch	2	0.85%	7.9 to 8.6
Modified fixed partial dentures	6	2.54%	3.7 to 4.2

Data retrieved from the records demonstrated no fracture at the band and wire joint in all cases (100% success rate). 127 SMs were removed as accomplished their purpose and 109 were still in function (Figure:2). Patients' gender and age had no significant effect on SM survival.

**Figure (2):** Percentages of the fate of SMs included in the study.

Discussion:

Several clinical studies have reported failures of soldered band and loop SMs where cement loss was the most common reason followed by silver solder breakage^[6-10]. Moore & Kennedy (2006)^[11], retrospectively evaluated the survival of 482 bilateral SMs. They reported that 114 failures evolved (24%) and solder breakage accounted for 10% of the failures (12 SMs).

Most mechanical failures of fixed SMs are attributed to silver soldering procedures; such as incomplete solder joint, overheating of the orthodontic wire, thinning of the wire by excessive polishing, and failure to encase the wire in the solder^[7,8,11,12]. It is suggested that poor design and construction may play a greater role in SM failure than patient cooperation or degree of mental development^[12].

Another point of concern for silver soldered SMs is the reduced corrosion resistance as a result of galvanic corrosion between different types of metals. High corrosion rates can influence mechanical strength and biocompatibility^[4, 13].

On the contrary, both safety issues and mechanical considerations encourage

the shift to laser welding. Laboratory tests revealed that laser welding provided superior mechanical strength and microhardness of joints compared to silver solder^[5, 13]. Regarding safety, laser-welding is a more biocompatible alternative than silver soldering which is cytotoxic for osteoblast differentiation, fibroblast viability, and keratinocyte growth^[14-16]. Moreover, immersion in different mouth washes resulted in higher metal ion release from silver solder than laser welding^[17].

Despite the proven benefits of laser-welded appliances, silver-soldered SMs are routinely used in pediatric dental practice and the literature has been scarce regarding testing the clinical longevity of laser-welded ones. The current study was designed as a retrospective cohort study to gain the advantages of having a large sample size including various types of SMs as well as a long follow-up without dropout^[18].

A strength of the retrospective cohort design is the immediate ability to afford information. It is also inexpensive to conduct^[19]. However, the investigator has no control over the data collection

procedures and accuracy relies on the quality of recorded information^[20].

The current study was designed as a single-group study which is often encountered with strong therapy preferences and with emerging therapeutic interventions. Although it lacks a direct comparator, both explicit and implicit comparisons are frequently made. Moreover, ethical concerns can be a determining factor in conducting such studies^[21].

A period of two years of follow-up was set since the mean survival times reported were; 20 months for the mandibular lingual arch, 23 months for the Nance appliance, and 16 months for the band and loop silver soldered SMs^[11, 12, 22]. Records evaluated belonged to newly constructed SMs, not recementation, repair, or replacement of the original ones since recemented, repaired, and replaced SMs survive longer as they function for a few months then removed, which confounds the results^[11, 12].

Data retrieved from the patient's records demonstrated no fracture at the band and wire joint in both unilateral and bilateral laser-welded SMs through out the follow-up period. This success rate

supersedes what was stated in the literature for silver-soldered SMs^[3]. It is note worthy that data were retrieved by 2 independent investigators blind to the aim of the study to overcome any source of selection or information bias.

Based on this astonishing clinical performance, further clinical studies are required to assess the success rate of laser-welded space retainers and orthodontic appliances. In addition, further laboratory studies are required to determine the weldability of different wire materials, and the best laser-welding machine parameters to ensure an optimal mechanical strength of laser weld joints for pediatric and orthodontic purposes.

Conclusion: Laser welded SMs provide a superior alternative to conventional silver soldered ones.

Abbreviations:

Space maintainers: SMs.

Declarations:

- Ethics approval: The study was approved by the Ethical Committee of the Faculty of Dentistry, Minia University (reference no. 840/2023).

- Availability of data and material: All data generated during this study are included in this article.

- **Funding:** No funds, grants, or other support was received.

- **Acknowledgements:** The author greatly appreciates the efforts in data acquisition of the assistant lecturers; in the Pediatric and Community Dentistry Department, Faculty of Dentistry, Minia University, Mohamed Abo Alftooh Shehata and Mahmoud Mostafa Abdelhakim.

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