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Soldering and Welding- In Dentistry: A Review.

Dr.B. Lakshmana Rao,

Prof & HOD, Dept of Prosthodontics, Lenora Institute of Dental Sciences, Rajahmundry, A.P.
Mail: kushulubathala@gmail.com

ABSTRACT

In prosthodontics and orthodontics, dental soldering and welding are the basic ways to combine metal parts. When you solder, you use a filler alloy that melts at a lower temperature than the metal you are working with. When you weld, you utilize localized heat to combine metals with or without filler. Soldering is a common way to make and fix fixed partial dentures, orthodontic appliances, and removable prostheses. It uses solders, fluxes, and antifixes to make sure that the joints are correct and that the distortion is kept to a minimum. Welding, especially laser and micro-pulse welding, is more accurate, doesn't cause much thermal distortion, and lets you combine materials like titanium and cobalt-chromium without using flux. Recent improvements include the use of laser and micro-pulse technologies, the creation of universal solders with built-in flux, the integration of CAD/CAM and additive manufacturing workflows, and better parameters for specific alloys. Future developments suggest an increased dependence on digital planning, intraoral welding, biocompatible and corrosion-resistant materials, and smaller devices equipped with automated presets. The goal of this review paper was to give an overview of the rules, tools, methods, recent developments, and future directions of dental soldering and welding.

Keywords: Dental soldering; Dental welding; Laser welding; Prosthodontics; CAD/CAM; Flux and antifix.

Introduction

Soldering in Dentistry

Soldering is a way to unite two metal parts by employing a filler metal (solder) that melts at a temperature below 450°C, which is lower than the melting point of the metals themselves.

Process: When heated, the filler pours into the joint through capillary action.

Uses in Dentistry: Used to connect elements of fixed dental prostheses, like crowns and bridges.

Putting together orthodontic tools.

Fixing broken metal frames.

Types: Pre-ceramic soldering: This is done before putting on the porcelain.

After applying porcelain, post-ceramic soldering is done at a reduced temperature.

Pros: Very little distortion when joining. Can be used to fix prostheses. Limitations: Not as strong as welding. If the alloys don't match, solder corrosion can happen.

Welding in Dentistry

In dentistry, welding is the process of putting two metal parts together by melting them together at a high temperature, usually without using a filler material in between.

Process: This means heating the metals in a small area (such using electric arc, laser, or resistance welding) until they melt or soften and stick together.

Uses in dentistry: o Putting together orthodontic wires and bands. Making and fixing metal frames, like partial dentures. Putting together titanium parts with laser welding. Used in orthodontics, prosthodontics, and implantology.

Pros: Makes joints that are sturdy. Reduces the need for filler materials. Helpful for small and accurate joints, especially when welding with a laser.

Limitations: Needs special tools. If not controlled, heat can change the characteristics of alloys. [1-5]

Key Difference

Welding = fusion of metals without filler.

Soldering = joining using a filler metal at a lower temperature.

Dental Soldering

Indications

Putting together parts of fixed dental prostheses, like crowns and bridges. Soldering before ceramics: before putting on porcelain. Soldering after ceramics: after firing porcelain (lower temperature). Fixing broken prosthesis frames. Putting together and fixing orthodontic appliances.

What not to do

Use within the mouth (since it needs a lot of heat). When corrosion resistance is very important and there is a chance of a solder–alloy mismatch. When you need a lot of strength (welding is best).

Benefits: Not too hard and not too expensive. Can be done with simple tools found in a dental lab. Little distortion if the right approach is used. Helpful for fixing or lengthening prosthesis.

Cons: Joints that are weaker than welding. If the solder and the parent alloy don't work well together, they can rust. Needs careful management of the gap and the heat. Not safe to use within the mouth.

Dental Welding

Signs

Putting together orthodontic wires, bands, and appliances. Making and fixing removable partial denture (RPD) frameworks. Welding together titanium parts like bars and implants. Situations when you need strong, exact joints, like laser welding in prosthodontics. What you shouldn't do: When heat could affect porcelain or ceramic restorations. In alloys that are sensitive to structural changes caused by high heat (like some Co-Cr alloys). When you don't have access to specialist welding tools, such as a laser.

Pros: Joints that are very strong, almost as strong as base metal. No filler material needed (the parent metals fuse together). Localized heating reduces distortion (particularly when welding with a laser). Can be utilized inside the mouth for little repairs (laser).

Cons: Needs costly tools, like the Nd:YAG laser. Depends on the skill of the operator. The possibility of changes in metal characteristics due to heat.

Not all alloys can use it. [1–5]

Difference Between Welding and Soldering in Dentistry [1-5]

Feature	Welding	Soldering
Definition	Joining of metals by fusion, without filler, using high temperature or energy (e.g., laser, resistance welding).	Joining of metals using a filler metal (solder) with a melting point below 450 °C, lower than the parent metals.
Temperature	High (can exceed melting point of parent metal).	Relatively low (<450 °C, below parent metal's melting point).
Filler Metal	Usually not required ; fusion occurs directly.	Required (solder acts as filler and flows into joint).
Strength of Joint	Stronger, nearly as strong as parent metal.	Weaker compared to welded joints.
Applications in Dentistry	- Laser welding of titanium components. - Orthodontic wire and band joining. - Repair/fabrication of frameworks (e.g., RPDs).	- Joining components of fixed partial dentures (FPDs). - Pre-ceramic and post-ceramic soldering. - Orthodontic appliance repair.
Advantages	- High strength joints. - Precise, localized heating (especially laser). - No need for solder.	- Easy, inexpensive. - Minimal distortion. - Good for repairs and joining delicate parts.
Limitations	- Requires special equipment (e.g., laser). - Risk of heat damage if uncontrolled.	- Weaker and less durable. - Corrosion risk if solder and parent metal mismatch.

Classification, step-by-step procedure (dental bridge), and materials for soldering

1) Classification of soldering used in dentistry

By time (clinical/lab stage)

Pre-ceramic soldering (sometimes called pre-soldering) is done before porcelain or ceramic veneering (typically using high-fusing solders).

Post-ceramic soldering (or post-soldering) is done after burning porcelain. It needs lower-fusing solders and particular protection for ceramic surfaces.

By the range of processing temperature and fusing

High-fusing (hard) solders are used for repairs before ceramics and when high strength is needed. They melt at about 950–1,200 °C.

Low-fusing (flow/soft) solders are used for work after ceramics or repairs after ceramics. They melt at about 700–900 °C.

Based on chemical makeup

Noble gold-based solders that don't rust easily.

Silver-based solders (good flow but more likely to tarnish or corrode in the mouth; mostly used in orthodontics and labs).

Base-metal solder alloys for Ni-Cr/Co-Cr frameworks (specialized solders or brazes).

By method or tool: torch (open-flame) soldering, furnace/oven soldering (investment/soldering muffle or vacuum furnace), induction/furnace, and unique lab procedures. (Laser is usually used for welding, not regular soldering.)

2) The things you'll need for the soldering process

1. Parent metals or frameworks (cast crowns, frameworks: gold alloys, Pd-Ag, Ni-Cr, Co-Cr, Ti—pick solders that work with them).
2. Solder (filler alloy): Choose the right strip, rod, foil, or strip solder based on how well it works with other materials and the right processing temperature (high-fusing vs. low-fusing; gold or silver based as needed).
3. Flux: a de-oxidizing flux (like borax or boric acid or dental flux) that breaks down oxide deposit and helps wetting.
4. Soldering investment or soldering base: This is a ceramic-bonded investment for furnace soldering or an investment rack/muffle.
5. Use soldering splint, modeling resin, sticky wax, or Duralay to hold components in place and keep them stable for investment.
6. A gas torch (propane/air or propane/oxygen), a laboratory furnace or vacuum furnace, or an oven for controlled heating.
7. A pre-heating furnace is used to burn off resins and manage the preheat (for example, ~600 °C for 10 minutes in many protocols).
8. A pickling or cleaning solution, like sodium-bisulfate/Sparex other dental pickling compounds, to get rid of oxides and flux after soldering.
9. Tools for preparing the surface: a 50 µm Al₂O₃ sandblaster, fine rotary tools, and a polishing kit.
10. Ventilation and personal protective equipment (PPE).

Step-by-step guide on soldering a 3-unit metal/metal-ceramic bridge

There are two workflows:

A. Pre-ceramic (which is better for metal-ceramic frameworks) and B. Post-ceramic (for after porcelain firing or repairs). Use the alloys and solders that the manufacturer says to use.

A—Pre-ceramic (before soldering)—the usual lab workflow

1. Plan and Select the solder. Pick a high-fusing solder that works with the parent alloy (try to match the composition and CTE as nearly as possible).
2. Try out and make a wax-up or assembly. Make sure the parts sit still on the model and provide a gap for soldering where needed. Stress-free secure parts.
3. Get the surfaces ready for soldering by roughening or finishing the contact regions (use 50 µm Al₂O₃ to grind or sandblast them) and getting rid of any dirt, oil, or grease.
4. Make the solder gap. The walls should be 0.05 to 0.20 mm apart to improve capillary action. Flow is less effective when anything is too wide or too narrow.
5. Stabilize the assembly by using modeling wax or resin to hold the pieces together. If you want to utilize furnace soldering, make a small soldering base or sprue system.
6. Invest: Put the assembly into the right soldering investment (follow the mixing and setting timeframes given by the investment maker).
7. Burnout or preheat: Use steam or hot water to get rid of the wax or resin, and then put the invested assembly in a furnace to preheat it (usually to around 600 °C for 10 minutes to get rid of organic residues).

8. Put flux on and place solder. While the solder is still warm, put the right kind of high-fusing flux into the solder gap and put the solder (either a strip or a formed ball) in the reservoir (feed solder from the colder side).

9. Soldering: heat until it flows

For furnace (investment) soldering, heat the area under the recommended environment (vacuum or inert) to about 50 °C above the solder processing temperature so that the solder flows by capillarity.

Torch soldering: Use the right torch (propane/air or propane/oxygen) and heat uniformly so that the soldering site reaches solder liquidus and the solder flows into the gap. Keep the flame in a small area and don't let it become too hot.

10. Let the assembly cool down slowly to room temperature. This will prevent thermal shock and distortion.

11. Get rid of and clean: get rid of the investment and blast 50–100 µm Al₂O₃ to get rid of oxides and flux. For precious alloys, apply pickling (such as PCT acid or a recommended pickling solution) to get rid of any leftover material.

12. Finish and polish: carefully grind and finish (don't make the solder too thin), then polish and move on to porcelain veneering as planned.

B — post-ceramic (repair after porcelain firing)

1. Check if it's possible: post-ceramic soldering adds heat to ceramic, therefore use low-fusing solders and cover the ceramic with wax or platinum foil. If the alloy isn't precious, you might not want to solder it after.

2. Protect porcelain by covering any ceramic surfaces with wax so that the investment doesn't touch them. Also, keep flux away from porcelain because it can discolor or crack ceramic.

3. Get the assembly ready and attach it to a tiny soldering base (or with support pins) and invest it with ceramic-bonded soldering investment.

4. Preheat: Put the object to be soldered in a ceramic furnace at 450–600 °C for 6–10 minutes, then raise the temperature to the solder processing temperature at a maximum rate of 50 °C/min (to avoid thermal shock and changes in the CTE of the porcelain).

5. Use as little flux as possible and solder under vacuum or carefully with a torch or furnace. Make a solder ball to hold the solder and make sure it doesn't touch the ceramic.

6. Cool down carefully, take off the glaze, clean (pickling), and finish. This is the same as before ceramic, but check the ceramic for crazing or color change. Postsoldering can modify the porcelain CTE and glaze, so be careful.

Helpful hints and how to fix problems

Gap matters: greater gaps (within limitations) improve joint strength up to a point — several studies demonstrate improved strength with gaps in the ~0.1–0.3 mm range, but very wide gaps (>0.76 mm) might cause difficulties with distortion and shrinkage. (Stade 1975 experimental evidence).

Flux and oxidation: Use flux right before soldering. Oxide development stops wetting and solder flow. Use the right flux: high-temp flux for pre-ceramic solders and low-temp flux for post-ceramic solders.

Start with a pre-fusing (high-fusing) solder. If you might need to make repairs later, use a higher-fusing solder first so that you can use lower-fusing solders subsequently.

Don't let flux touch porcelain (it will change color or crack). Use wax or foil to protect ceramic surfaces.

Pickling safety and disposal: Pickling solutions are acidic, so you have to follow the rules for how to handle and get rid of pickled metal waste. Follow the instructions on the SDS for using commercial pickling chemicals.

When to use welding: laser welding or resistance welding may be better for small, precise, high-strength repairs inside the mouth, like titanium implant parts. This is welding instead of soldering.

Quick lab card (short checklist)

Choose a compatible solder after choosing a parent alloy. Get the surfaces ready: sandblast 50 µm Al₂O₃ and leave a gap of 0.05–0.20 mm. Secure on model → invest → preheat (600 °C, 10 min for pre-ceramic) → flux → solder → heat to flow → slow cool → divest → blast/pickle → finish. **[1,6-11]**

Flux in Dental Soldering

During soldering, flux is a chemical that is put on metal surfaces to get rid of or stop oxide from forming, make the solder more wettable, and make sure the molten solder flows properly into the junction.

What Flux Does and How It Works

1. Takes off any oxides that are already on the surfaces of the parent metal.
2. Stops more oxidation from happening when heating.
3. Reduces the surface tension of molten solder, which makes capillary flow better.
4. Makes the bond between the two pieces of metal stronger by making sure they touch cleanly.
5. Sometimes it shows the temperature (the flux changes color and becomes glassy when it becomes hot enough to solder).

Types of Flux (depending on how they work)

Surface protection flux: This coats metal to keep new oxide from forming.

Reducing flux: This chemical process gets rid of oxides.

Solvent flux—dissolves and takes in oxides that are already there.

Flux Materials Used in Dentistry

Borax (sodium tetraborate) is the most popular type. It dissolves metal oxides. Boric acid—used with borax to make fluxing work better. Potassium fluoride (KF) works well with base-metal alloys and breaks down tough oxides. Silica, sodium carbonate, and lithium borate are all added to proprietary dental fluxes. Commercial dental fluxes are normally made up of borax, boric acid, and fluoride salts in different amounts, and they are often sold as powders or pastes.

Benefits of Flux

Makes a clean surface without oxide. Improves the flow and strength of solder. Helps joints stay tight and keeps voids from forming. Necessary for joining both noble and base-metal alloys (base metals need stronger flux containing fluorides).

Antiflux in Soldering Teeth

Antiflux is a substance that is put on places where solder flow needs to be stopped. It stops solder from spreading where it shouldn't by acting as a barrier.

What Antiflux Does and How It Works

1. Directs the flow of solder to the gap that has been prepared.
2. Stops too much soldering and cuts down on the requirement for finishing and grinding.
3. Keeps regions like porcelain edges or surfaces that aren't meant to be linked safe.
4. Makes soldering more accurate and less wasteful.

Materials Used to Stop Flux

Graphite (pencil lead/carbon slurry) is a conventional antiflux that makes a physical barrier. Rouge (ferric oxide) is used as a paste or solution. Chalk (calcium carbonate) makes a coating that doesn't dissolve. Correction fluid (titanium dioxide suspension, like "Tippex") is a common modern antiflux in dental labs. There are also commercial antiflux paints.

Benefits of Antiflux

Gives you control over how the solder spreads. Stops damage to the porcelain edges next to it. Shortens finishing time and stops the structure from being weaker from too much grinding. [1–5]

Flux vs. Antiflux Aspect Flux Antiflux Purpose Removes or stops oxides and helps solder flow. Keeps solder from going where it shouldn't

Effect: Improves bonding and capillary action; stops solder from spreading.

Some examples Potassium fluoride, boric acid, and borax Graphite, rouge, chalk, and correction fluid

Recent Advancements in Dental Soldering / Dental Joining

1. Updated Technical Review of Soldering

A 2024 review "*Soldering in Dentistry: An Updated Technical Review*" (Cumbo et al.) covers recent evidence about joining techniques, materials, and improvements in controlling distortion, biocompatibility, and process standardization.

2. Increased Adoption of Laser Welding as Alternative to Soldering

- Laser welding (especially Nd:YAG, pulsed lasers) is being used more to replace torch/gas soldering. It reduces distortion, provides more localized heating, better control, and improved mechanical properties of joints.

- A study comparing three-unit fixed prostheses found that **laser-welded** and **one-piece cast** frameworks undergo significantly less distortion than those joined by conventional soldering.

3. **Material Improvement: Better Alloys & Flux / Solder Combinations**

- Work on Ni-Cr and Co-Cr alloys to optimize their weldability (or solder-ability), e.g., noting that slight chemical changes in Ni-Cr have large effects on joint quality; Co-Cr shows good weldability with lasers.
- Also, newer solder materials / pastes are being tested for **biocompatibility**, cytotoxicity, etc. For example, different silver solder materials (traditional silver solder, universal silver solder, solder paste + flux) were compared for cytotoxic effects; some show high non-viable cell counts, indicating that choice of solder/paste matters for biologic safety.

4. **Devices & Automation**

- Better welding / soldering devices: e.g. micro-pulse welding units (PUK D series) that give very short, powerful pulses, enabling work on thin sections with lower collateral heat effects. These devices allow finer control of the heat, thus preserving adjacent ceramic/acrylic parts.
- Integration of CAD/CAM & additive manufacturing (AM) – frameworks are being designed digitally; after 3D printing or laser melting, joins may be needed (e.g. combining printed parts). Better planning for solder joints / welds in these digitally designed prostheses. Some reports note use of lasers, better solder/resin mixes, etc.

5. **“Universal Solder” / Solder with Integrated Flux**

- Products are appearing that combine solder with flux in one stick/rod, simplifying the process, ensuring correct flux distribution, reducing time & error. E.g. a silver-based brazing (solder) with built-in fluoride flux (Universal Solder). This reduces steps, potentially reduces oxide formation by ensuring flux is exactly at the solder interface.

6. **Improved Understanding of Distortion and Microstructure**

- More empirical studies quantifying distortion (dimensional changes) after soldering vs laser welding vs casting one-piece. These help set parameters (gap size, heating/cooling rates).
- Metallographic examination of welded/soldered joints in newer alloys to see how microstructure (grain boundaries, heat-affected zones) changes, and how that affects properties like hardness, corrosion resistance.

7. **Safety / Biocompatibility**

- More attention being paid to cytotoxicity of solders and fluxes. As mentioned above, the study of silver solders and their pastes flux combinations shows substantial cytotoxic effects depending on composition.
- Also, in welding (laser), less risk of introducing new materials or mixing alloys if welding uses same alloy components rather than adding filler or solder of different composition. (Some innovations are focused on matching alloy types to reduce corrosion or galvanic effects.)

Dental welding — materials, step-by-step procedures, recent advances and future trends [15,19-23]

Limitations and Areas Requiring Further Investigation

- There are less long-term clinical trials of contemporary solder materials and procedures.
- In many places, the cost and availability of equipment are still problems.
- Making sure that protocols (such heating and cooling speeds, gap sizes, and flux compositions) are the same in all labs and alloy systems.
- How these new solder and flux compounds affect fatigue and corrosion in the mouth over many years. **[12-14]**

Trends in dental soldering for the future

1. Change from traditional soldering to laser micro-welding and pulse-welding tools

When compared to torch soldering, laser welding (Nd:YAG and pulsed systems) and micro-pulse units (PUK/PUK-type welders) give forth very focused energy, less heat spread, and less distortion. Expect more labs and clinics to use it for repairs and work inside the mouth (connecting titanium and Co-Cr pieces with accuracy).

2. Joining in the mouth or at the chairside

Fiber-delivered Nd:YAG lasers and specialized intraoral welding devices enable precise joins to be executed immediately within the oral cavity (implant bars, temporary frameworks), hence decreasing laboratory turnaround time and enhancing fit during intraoral trials. Clinical protocols and evidence are growing, although they still depend on the technique used.

3. Combining with digital processes (CAD/CAM and additive manufacturing)

Digital design and fabrication (milled or selectively laser-melted frameworks) will modify how and where connections are designed. Designers will put mechanical joints together, test-fit them digitally, and pick how to join them (laser weld, brazing, or printed single-piece frameworks). This makes it less likely that you will need to do corrective soldering and makes it easier to reproduce.

4. New solders, solder pastes, and "all-in-one" solutions that come with built-in flux and low-toxicity formulas

Companies are making solder pastes and rods that are easier to use (with built-in flux or designed melting ranges) and that are less poisonous and corrosive in the mouth. Look for more solder chemistries that work well with base-metal alloys and digital metal operations.

5. Pay attention to how well it works with living things and how resistant it is to corrosion.

There is more focus on the cytotoxicity of solder, flux residues, and galvanic interactions. In the future, practice will focus on choosing solder/flux combinations that have been shown to be low in cytotoxicity and resistant to corrosion over time, as well as better pickling and cleaning methods.

6. Making things smaller and better at controlling heat to safeguard nearby ceramics and polymers

New welding units and process controls (such micro-pulse, ultra-short laser pulses, and vacuum/argon atmospheres) lower the amount of heat that affects the area around the weld, which means that you may join porcelain, composite, and acrylic without damaging them. This opens up more options for repairs in the clinic.

7. Automation, reproducibility, and methods that are the same for everyone

As labs start using digital planning, vacuum furnaces, soldering in an inert atmosphere, and pre-programmed laser settings, soldering will become more consistent and less reliant on the person doing it. Research is progressing towards the establishment of defined parameters (gap size, heating ramps, flux types) for prevalent alloy/solder combinations.

8. Working together with surface engineering and nanotechnology

Surface treatments including nano-coatings and better oxide-control procedures, as well as fluxes or solders that are augmented with nanomaterials, may make wetting, joint strength, and antibacterial qualities better while lowering corrosion. This is a new area of research that could lead to real-world applications.

9. Improvements to the environment, safety, and rules

Safer flux chemistries, appropriate disposal of pickling solutions, and stricter rules about the materials used in the mouth will make manufacturers and labs look for greener, safer soldering options and make sure they follow SDS/SOP rules.

10. Soldering will still be used as a repair method, but only for certain things.

Soldering will still be required for some repairs, such bridges and clasps, but it will be used less often. When long-term strength and corrosion resistance are important, laser or one-piece digital solutions will be used. In a hybrid approach, soldering will work alongside welding and printed single-piece fabrication.

What this means for doctors and technicians in real life

Teach workers how to use lasers and PUK welding, as well as how to plan digital joins. Check the biocompatibility and corrosion resistance of the solder and flux you choose; keep up with the latest research. When you can, make frameworks that cut down on the need for corrective soldering (for example, utilize a one-piece digital design or arrange for controlled weld zones). [12,15–18]

1. Short definition / context

Welding in dentistry means putting metal components together by melting the parent metals together (autogenous or with filler) to make a single metallurgical junction. Laser welding (Nd:YAG / fiber / Yb sources) and micro-pulse (PUK) welders have mostly replaced torch procedures in dentistry labs because they make very localized heat, small heat-affected zones, and robust joints.

2. Things that are utilized for dental welding

2.1 The main metals

- Titanium (CP-Ti) and Ti alloys (e.g., Ti-6Al-4V / Roxolid variations) are often used for implants and bars. When welded, they need to be protected from argon and other gases.
- Cobalt-chromium (Co-Cr) alloys are often used for RPD frameworks and implant bars. They can be welded with a laser or PUK if the right settings are used.
- Nickel-chromium (Ni-Cr) and stainless steel are used in some frameworks and orthodontic pieces. (Note that they can be hard to weld, and the amount of nickel in them can change the quality of the weld.)
- High-noble gold alloys and Pd-based ones can be welded, but they need different amounts of energy since they absorb more.

2.2 Filler and other supplies

When you need a filler, use welding wire or rod made of the same alloy (for example, carbon-free Co-Cr welding wire, remanium® or rematitan® wires for Co-Cr / Ti instances). For the optimum compatibility, use wires made by the same company.

2.3 Gases and atmospheres that protect

Argon (an inert gas) is the typical way to protect the molten weld pool (particularly for Ti) from oxidation and embrittlement. Welding in argon or a regulated atmosphere makes the weld more resistant to corrosion and more compatible with living things.

2.4 Accessories, tips, and electrodes

Tungsten or special electrodes for TIG/TIG-micro pulse systems, diamond-grind tips for PUK electrodes, and matching welding microscopes with optical magnification and certified eye protection.

2.5 Cleaning and preparing the surface

- For a matte finish, use Al_2O_3 sandblasting (50–150 μm), ultrasonic cleaning, pickling solutions for leftover paint, and polishing kits.

3. Step-by-step guide for laser welding (typical Nd:YAG/fiber laser workflow)

The exact settings (pulse, energy) depend on the device and the alloy. Use the settings that the manufacturer suggests. The steps below are based on common, evidence-based practice and advice from Dentaaurum/Lampert.

1. Plan and check: Check the fit of the framework on the master model and find the places where it is bent and has to be welded.
2. Preparing the surface: Clean the workpiece of dirt and dust, and sandblast the weld area (Dentaaurum: usually 150 μm Al_2O_3 for prosthetic components) to get rid of the shine and make it easier for the material to soak up. If you can, line up the parts so that they are flush (flat contact).
3. Stabilize / tack o Use light tack welds (or mechanical stabilization) to keep parts in the right place; tack from different sides to keep them from warping.
4. Choose filler (if needed) If there is a gap or point of contact, put a tiny piece of welding wire ($\varnothing 0.35\text{--}0.7\text{ mm}$) or a cast filler sheet into the gap. If there is full contact, autogenous (no filler) spot welding may be enough.
5. Shielding: Make sure the argon covers the weld location (the argon nozzle should be pointed at the weld). Inert atmosphere is very important for Ti welding to keep oxygen and nitrogen from getting in.
6. Choosing parameters and the welding method
 - o Choose the manufacturer's settings for the alloy and the job. For example, in desktop laser systems, the spot sizes should be between 0.8 and 1.2 mm and the pulse durations should be between 2 and 8 ms. The power and pulse should be changed from thicker to thinner parts. Use alternating weld sites (above and below) and keep an eye out for warping.
7. Cool down and check. Let the part cool down, then check the weld for metallic shine, continuity, and any fractures or holes. If you see any warping, re-weld the counterpoints.
8. Finish: Use sandblasting and pickling (according to the alloy SDS) to get rid of any oxidation. Then finish and polish the piece, and if you like, move on to ceramic veneering. Note: Don't let porcelain edges get too hot.

Safety: use eye protection, local extraction (fume control), and PPE when using a welding microscope. Don't breathe in welding fumes; follow the SDS for alloys.

4. Step-by-step: Micro-pulse/PUK welding (hands-on)

Many dental labs utilize PUK, which is impulse micro-welding based on capacitor discharge, as a laser alternative.

1. Fit and prep: make sure everything fits right and sandblast the weld interfaces to make them matte.
2. Prepare the electrode by shaping and cleaning the tip. Use the sizes of electrodes that the manufacturer recommends for the job.
3. Choose the type of metal and the scenario. The PUK menus have presets for Co-Cr, Ti, gold, and stainless steel. Choose one and confirm the energy and pulse length.
4. Tack and weld: small impulses (in the millisecond range) with pressure from the electrode; several short pulses are used to keep the heat from spreading. If you're welding reactive metals like titanium, use argon shielding.
5. Check the quality of the weld, clean it, and polish it.

(PUK has a smaller footprint than certain lasers, can be tuned to repeatable settings, and doesn't produce as much heat as other lasers. Many labs utilize it as a cheaper alternative to lasers.)

5. Recent advancements in dental welding (evidence summary)

- 1. A lot of people are using laser welding now, and better sorts of lasers, like pulsed Nd:YAG, fiber, and Yb lasers, provide you more control, fewer heat-affected zones, and reliable processes inside the mouth. Clinical and in vitro studies show that this method makes joints stronger and less likely to bend than traditional soldering.
- 2. Micro-pulse (PUK) welders have come a long way. The new small PUK devices (PUK D6 family) include with preset modes for popular alloys, retention/fixation modes, and easy-to-use interfaces, making precision welding easier for more labs.
- 3. Intraoral/immediate welding protocols—using Nd:YAG or spot-weld devices to weld implant bars inside the mouth allows for instant stability and a simpler workflow for immediate loading protocols. Case series and reviews show that this is possible as long as protocols and shielding are followed.
- 4. Integration with digital workflows and AM: As more frameworks are CAD/CAM machined or made by laser-melting, the way they are joined changes. Designers can either reduce the number of joins needed or plan weld zones. Studies demonstrate that additive manufacturing is changing how and where welding is employed.
- 5. Better knowledge of metallurgy and parameters that are specific to alloys—more articles show how the chemistry of the alloy (C, B, Ni content) and the laser parameters affect hardness, microstructure, and corrosion at the weld zone. This lets you optimize parameters for Co-Cr, Ni-Cr, and Ti.
- 6. Focus on health and the environment—more study has been done on welding fumes, safer pickling methods, and the biocompatibility of welded joints. This has led to better extraction, handling, and material selection.
- 6. Future trends (short list) • More miniaturization and cheaper laser/fiber options for chairside/intraoral welding.
- • Better integration of CAD/CAM and AM (designs that eliminate joins or put optimum weld locations on purpose; digital presets sent to weld equipment).
- • AI or automated parameter selection—devices that automatically advise pulse or energy based on the alloy and shape (new directions from vendors).
- • Nanocoatings and surface engineering to make lasers absorb better and welds stronger (research direction).
- • Standardization and evidence-based methods for welding particular to alloys (anticipated to be agreed upon by both industry and academia).
- 7. Useful tips and mistakes
- • Use argon gas for Ti. This is very important to keep it from becoming brittle and losing its biocompatibility.
- • When using filler, make sure the composition matches. To avoid galvanic and corrosion problems, use welding wires that the manufacturer recommends.
- • The tack-alternating approach cuts down on warping. To do this, tack on opposite sides and keep checking the fit.
- • Keep heat to a minimum near porcelain by carefully choosing micro-pulse/laser settings. If you plan to weld before veneering, or utilize specially controlled low-heat protocols for post-ceramic connections. [15,19-23]

Does CAD-CAM Denture Fabrication Require Soldering and Welding? [24-29]

CAD/CAM dentures are made using computers to design and mill or 3D print monolithic structures. These processes cut down on or get rid of the necessity for human joining methods like welding and soldering, which were utilized in the past to make metal frames for removable and fixed prostheses.

2. Soldering and Welding in Conventional vs CAD/CAM Dentures

Aspect	Conventional Denture Techniques	CAD/CAM Denture Systems
Framework fabrication	Metal frameworks for RPDs often required soldering/welding to join components.	CAD/CAM frameworks (e.g., milled cobalt–chromium or titanium) are monolithic , eliminating joints.
Repair/Modification	Soldering used for repair or joining fractured metal parts.	Repairs are often done digitally (re-scanning and re-milling). Welding may be used only for selective repairs (e.g., laser welding of titanium).
Accuracy and Fit	Potential for distortion due to heat from soldering/welding.	CAD/CAM milling ensures high precision and passive fit , removing need for joint fabrication.

Aspect	Conventional Denture Techniques	CAD/CAM Denture Systems
Material Type	Primarily metal-based components (Ni-Cr, Co-Cr, Hybrid or resin-based blocks, titanium, zirconia, or PEEK — not suitable for traditional soldering).	
Clinical Implication	Manual alignment and joining steps needed.	Fully digital process with minimal manual intervention or joining.

3. Present Use of Soldering/Welding in CAD/CAM Era

CAD/CAM dentures don't need to be soldered very often because the framework and base are made as one piece.

Laser welding can still be utilized to fix broken metal parts of a digitally machined framework.

Putting on clasps or attachments to CAD/CAM metal structures.

Welding within the mouth while making an implant-supported prosthesis.

CAD/CAM dentures are usually made digitally as solid frameworks that fit better and are more accurate. This means that they don't need to be soldered or welded. Laser welding is still useful for fixing or changing metal parts, notably in implant frames, but not very often. [24-29]

Conclusion

In prosthodontics, orthodontics, and restorative dentistry, dental soldering and welding are very important skills for joining and fixing metal parts. Soldering is still a cheap and useful way to make fixed partial dentures, fasten prostheses, and join orthodontic appliances. It uses filler alloys, flux, and antilux. Welding, especially laser and resistance welding, makes joints stronger, more precise, and less likely to warp. This makes it great for contemporary alloys like titanium and cobalt-chromium.

Recent improvements, such as the use of laser and micro-pulse welding, digital integration with CAD/CAM systems, and the creation of universal solders, have made these technologies more reliable and useful in clinical settings. Future trends point to a move toward digital planning, intraoral welding, and materials that are biocompatible and resistant to corrosion. This makes welding more popular than soldering for high-performance dental applications.

In general, soldering and welding go well together. Soldering is still a versatile and cost-effective option for everyday dental work, while welding is the best choice for accuracy, strength, and working with new digital workflows.

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