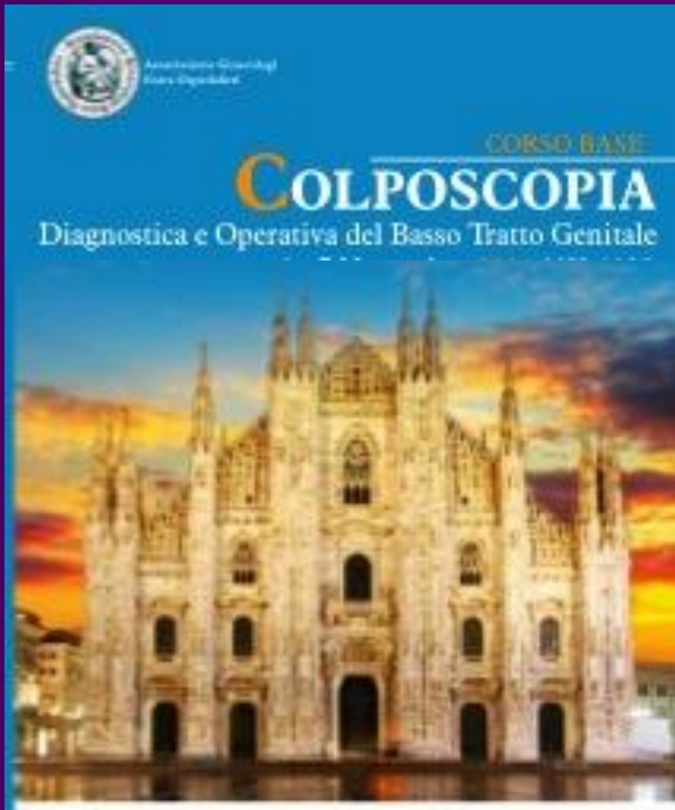

Principi di impiego del CO_2 laser

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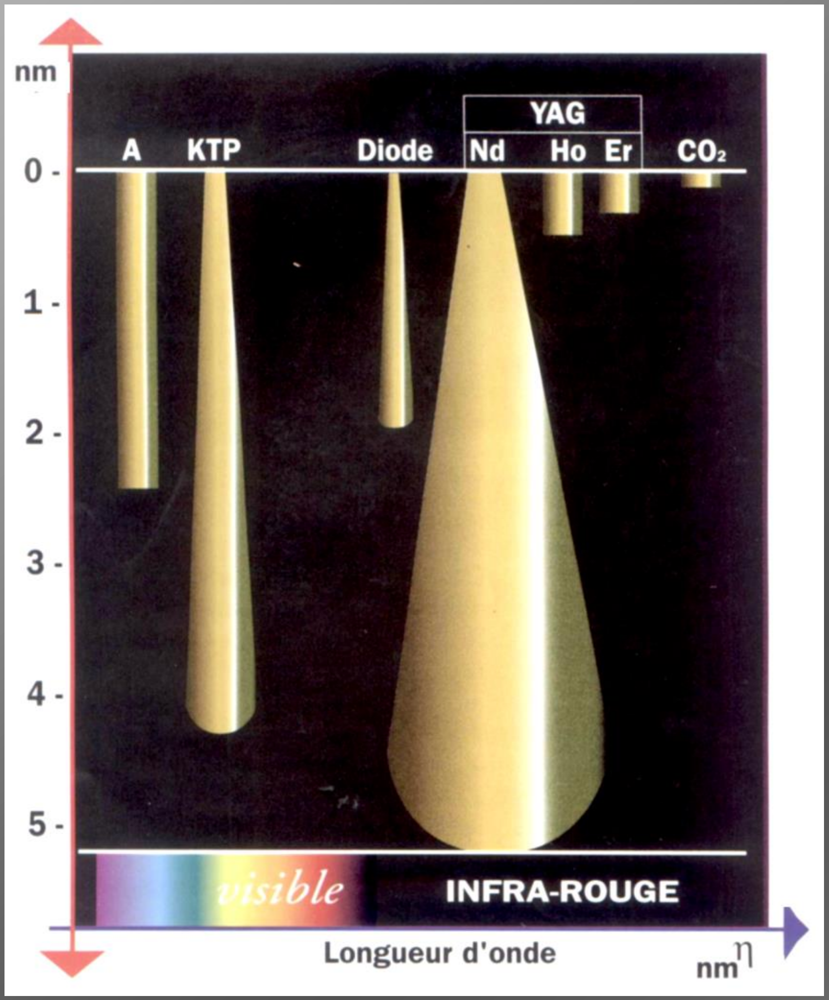
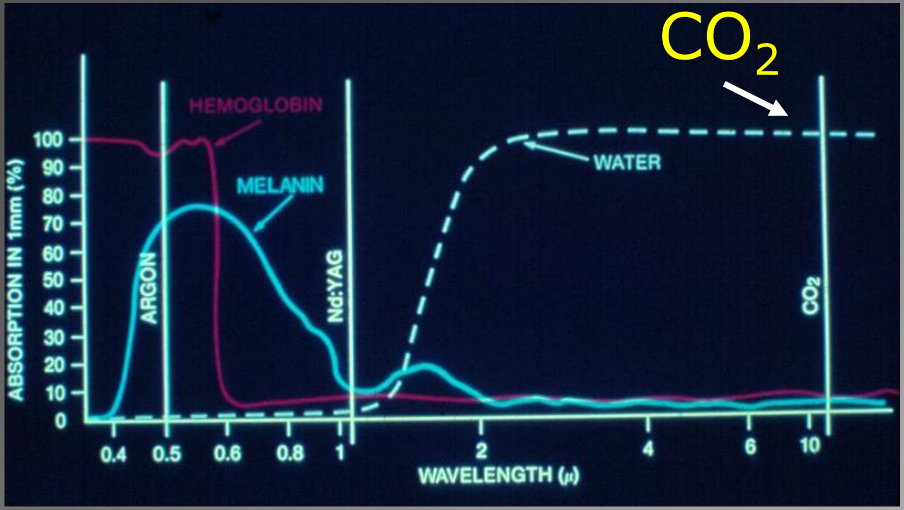
Main Types of Surgical Lasers



	CO_2	Argon/KTP	Nd:YAG
Type	Gas	Gas	Crystal
Wavelength	10.6 microns	488-514 nm	1.06 microns
Color	Far Infrared	Blue-Green	Near Infrared
Power	0-100 W	0-20 W	0-150 W
Penetration	0.2 mm	1 mm	5mm
Absorbed by	Water	Hemoglobin & Melanin	Tissue Protein
Delivery	Articulated Arm	Optical Fiber	Optical Fiber
Aiming Beam	He-Ne	Argon	He-Ne
Energy Efficiency	20%	0.1%	2%
Maintenance	Moderate	High	Low
Cutting	Good	Poor	Fair
Coagulation	Poor	Fair	Good



The *extinction length* is defined as the thickness of water that absorbs 90% of the radiant energy of the incident beam.

For the CO2 laser, this is approximately 20μ

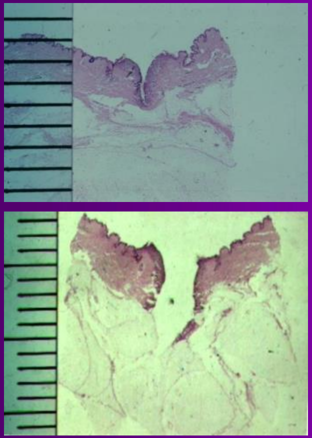
This property allows a potential for precise surgical control

Main CO_2 Laser terminology

Term	Definition
Energy (E)	is power multiplied by time of application, expressed in *joule, (*J=1 watt (W) x 1 second (sec).
Power	energy divided by the time of application, expressed in *watt. 1 W* = 1 J divided by 1 sec. (J/sec).
Power Density (PD)	or *irradiance,* rate of power divided by the surface area of the beam or beam spot size (W/cm2).
Trasverse Electromagnetic Mode (TEM)	The cross irradiance in a gaussian fashion (TEM 00), or in a doughnut fashion (TEM 01)
Variables of beam emission	Categories for CO_2 laser: 1 Continuous Wave (CW); 2 Computer assisted (scanning device); 3 Pulsed (super or ultra)

CO2 Laser Bioeffects :
Main physical factors influencing the shape of the crater

CO2 laser crater (stationary beam)

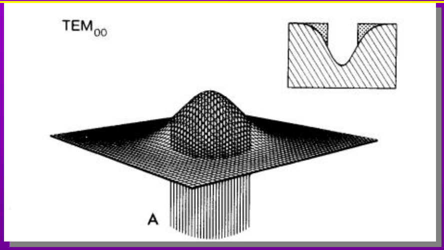


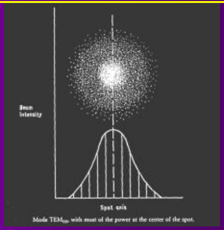
- Beam Spot Size → Width

- Exposure time
  - a. instrument (beam emiss. mode)
  - b. operator (speed)
- Power Density
- TEM

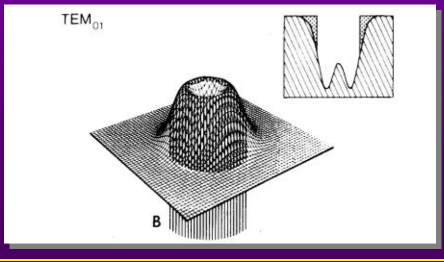
→ Depth

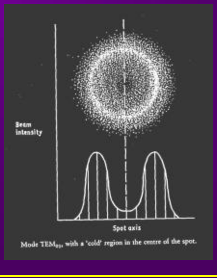
TEM 00: **The irradiance across the beam is distributed in a gaussian fashion peaking at the center of the beam and falling off to zero at the edges.**





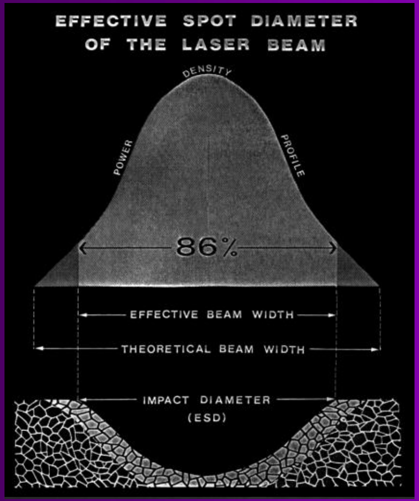
TEM 01: **The irradiance across the beam is distributed in a doughnut fashion, peaking at the edges of the beam and falling off to zero at the center.**

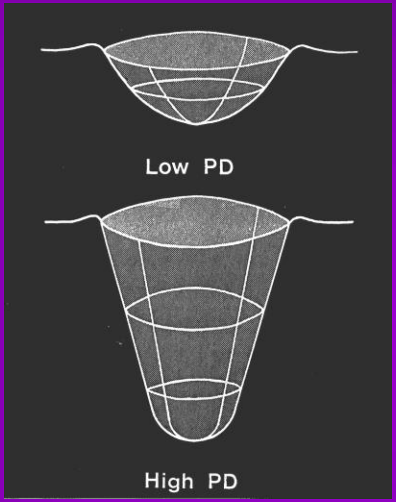


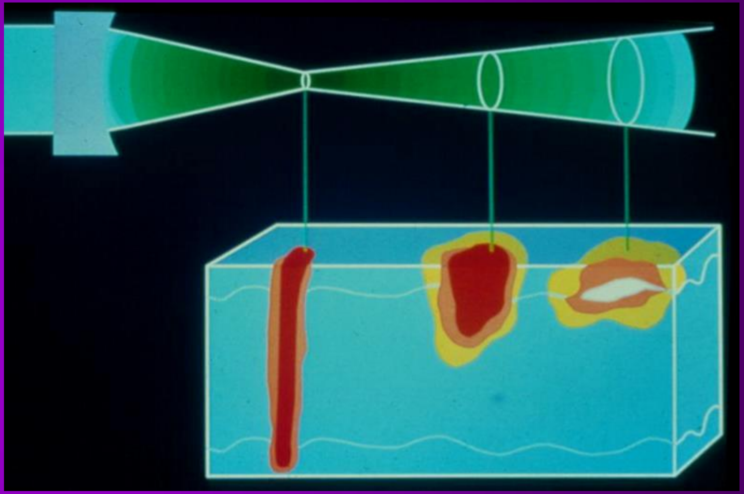


Spot Size

The spot size of the laser is controlled by focusing lenses or by moving the handpiece toward or away from the target tissue.
Small variations in distance and angle of incidence of the beam produces great alterations in the diameter of the beam spot size and consequently in power density, and crater configuration.

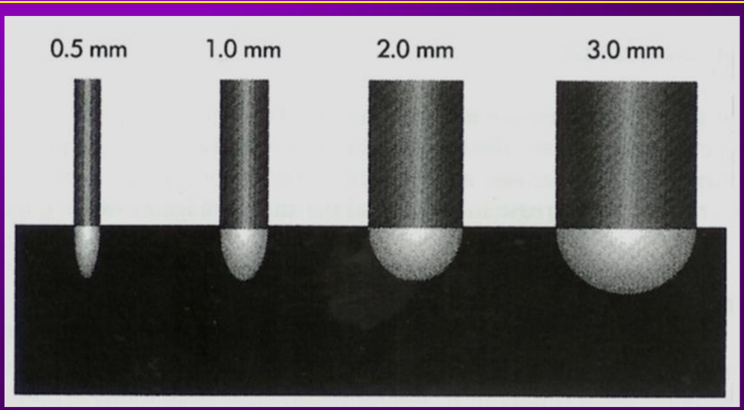






Smaller spot size creates incision, but bleeding.

Larger spot size allows for smoother, more uniform vaporization of tissue, but poor incision, and requires high power to compensate for the dilution of power density.



Variables of beam emission

Beam emission of CO_2 laser surg. systems can be classified into the following categories:

1 Continuous Wave (CW);

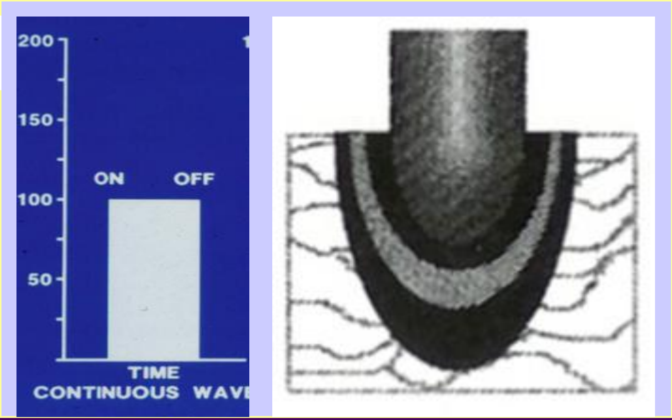
2 Computer assisted scanning device with a CW emission;

3 Pulsed (a. super and b. ultra)

1. The CW:

Hemostatic power for blood vessels of 0.5-2mm, but 500-3000 μm thermal damage, slower wound epithelialization, delay in epidermal migration (eschar), and increased wound infections

1



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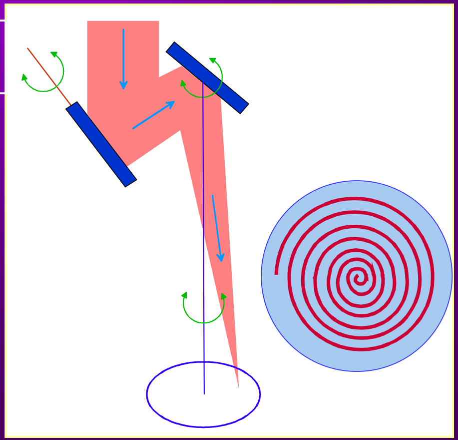
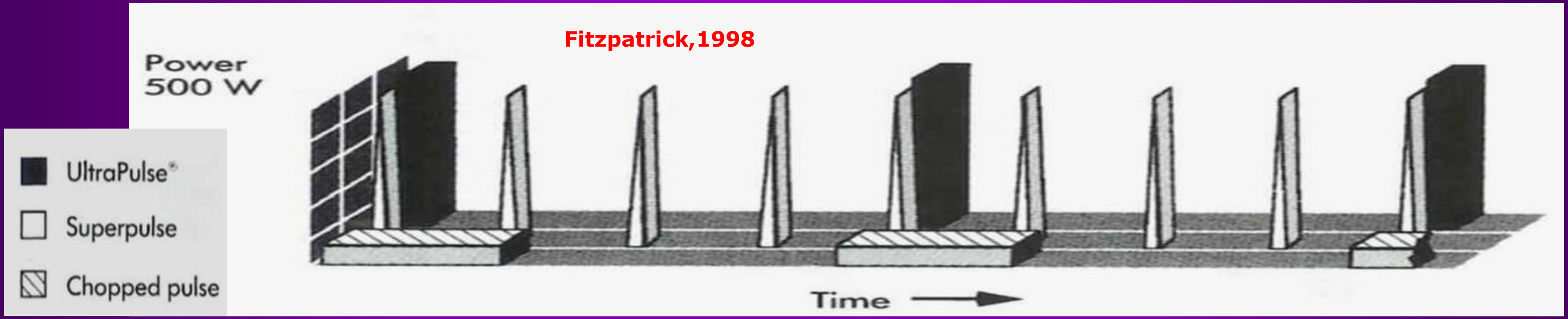


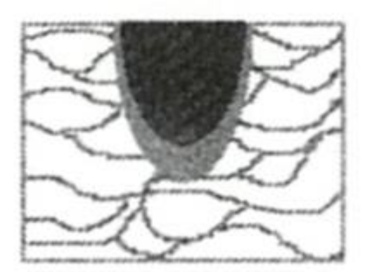
Variables of beam emission

3. Pulsed emission of CO_2 lasers produce precise tissue ablation with decreased peripheral thermal damage.

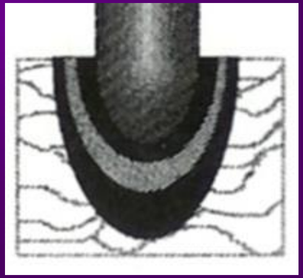
Superpulsed or ultrapulsed CO_2 laser can emit a controlled train of short-duration high-power pulses, produced by electronically pumping the laser tube. The peak powers are 10 times more than the CW mode laser.



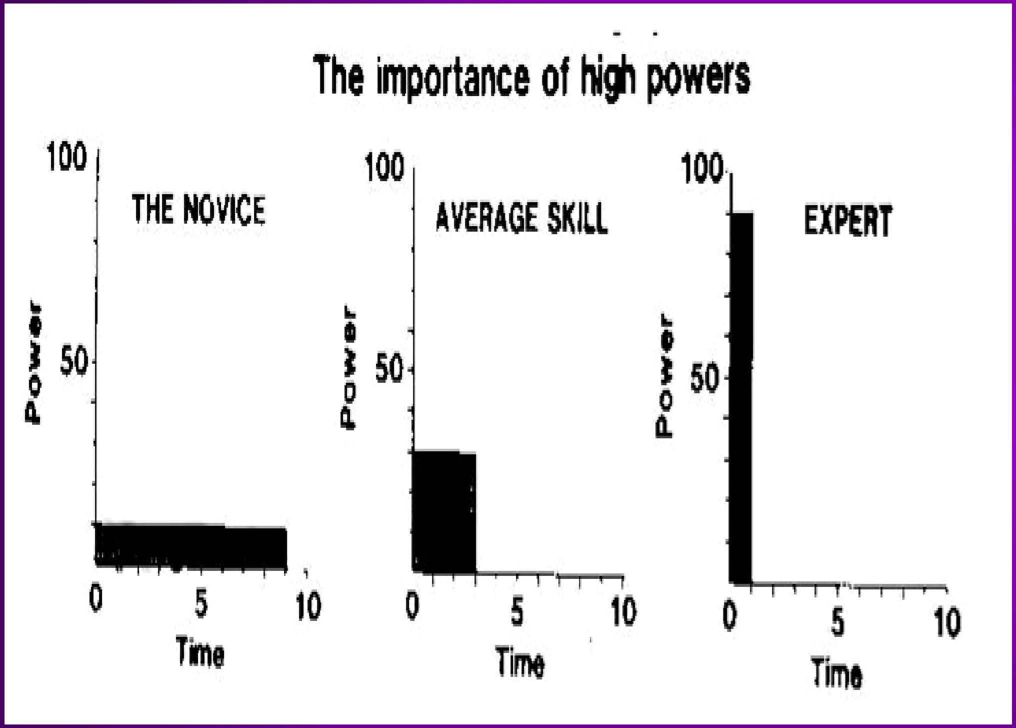
Ultrapulsed CO_2 laser:
Thermal damage caused by direct heating



Continuous CO_2 laser:
Thermal damage caused by direct heating and peripheral heat conduction



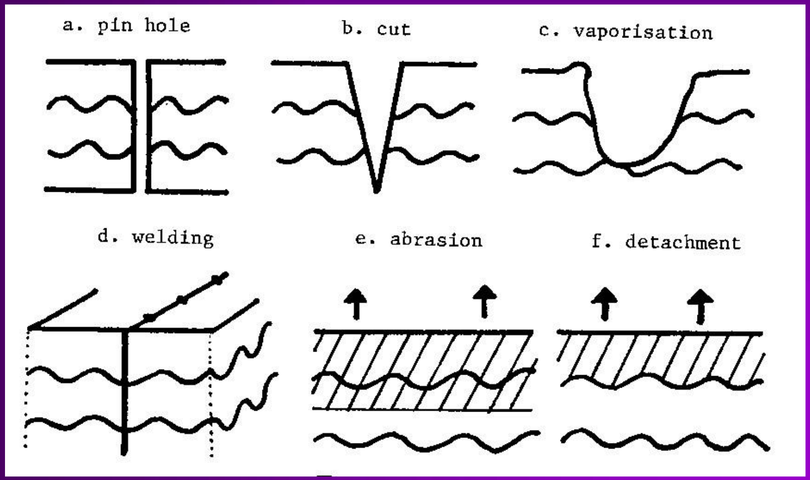
Surgical effects



- **Best procedure for cutting or vaporizing when using the highest controllable power density, within the effective beam spot Ø (the higher the power density used, the faster the beam has to be moved over the tissue surface)**
- **Minimal thermal damage when using high incisional speed**
- **Coagulation is performed at low power densities: by defocusing the beam to increase the spot ø, by reducing the power output, or both**

Surgical Effects

How laser works



Vessel coagulation

Shrinkage effect

The CO_2 laser beam can be used:

- **with a focused spot size (0.1-0.2 mm) for incisional-excisional surgery**
- **with a large-Ø spot (2-5 mm) for precise and hemostatic ablation (destruction)**

The ultimate objective of lesion removal can be obtained either :

- **by contiguous movements of the laser until the tissue destruction at the desired plane is reached,**
- **or by direct excision under the desired level**

Destructive effects:
Ablation, Abrasion,
Vaporization
Photothermolysis

Excisional effects
Incision,
Resection

Combined effects
Excisional +Destructive

Limitations of the destructive technique:

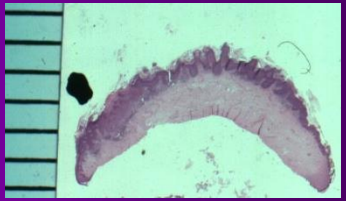
1. Lack of operatory specimen for complete histologic diagnosis, and removal completeness

2. Inter-operator variability, poor reproducibility, due to:
   -Variable angle of beam incidence (pencil like), with irregular ablation planes
   -Variable beam movement speed
   -Variable power densities, emission mode

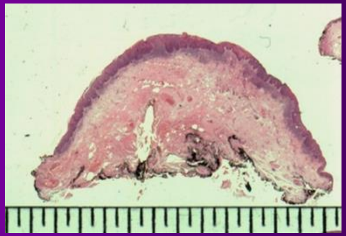
3. Time to vaporize the lesion increases with the lesion thickness, and it is longer with respect to expert excision time. This is proportional to the lesion surface extension instead of the volume. But thin lesions (less than 1 mm in thickness) are difficult to be excised.

4. Lymphatic vessel sealing along the tissue edges are irregular findings, thus rendering the incisional procedure in healthy tissue as preferable for premalignant or initially invasive disorders, rather than vaporization. The excision of tumor at a almost 1-2 mm distance out of lesion borders is advisable.

Tumor invasion (unexpected)



Excision borders in healthy tissue



Laser Plume

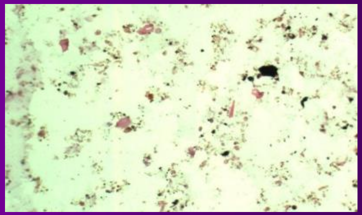
- **Plume of smoke** at the laser impact site during the vaporization of any tissue.
  Intact cells are nonviable in the laser plume.

- **Particulate matter of 0.1-0.3 µm Ø** range, can produce lacrimation, nausea, cramping and vomiting, and may transmit infectious agents.

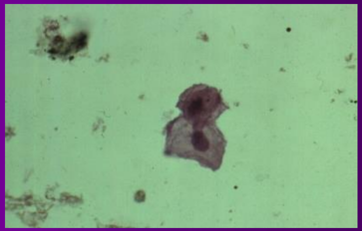
- **Bacterial spores** may survive in the plume at irradiances below 500 W/cm2, whereas at high fluences the CO2 laser sterilizes and devitalizes exposed tissue.

- The risk of potentially infectious particles from patients infected with **HCV or HIV** is of negligible entity.
  Viral DNA and virions of HPV *can be found* in laser plumes from vaporized warts using both pulsed and CW irradiation at both high and low irradiances. However, **HPV transmission** during a laser procedure has not been demonstrated.

Unrecognizable cell particles

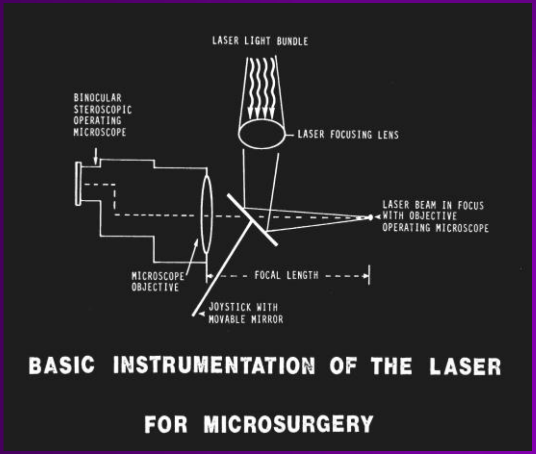


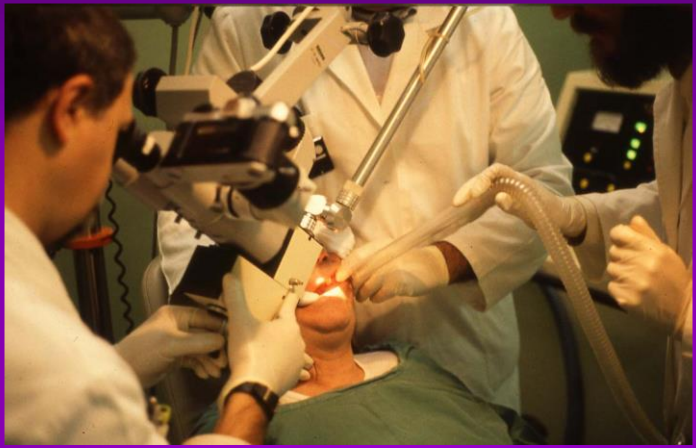
Unviable cells

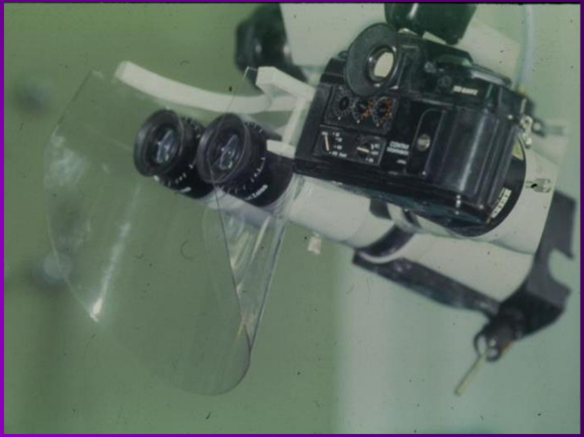


Microscopic versus Freehand Excision

Microscope coupled and micromanipulation technique







1. **Beam coaxial with microscopic viewing** and aiming beam visible through the optical lenses controlled with a **joystick,** distance 200-400 mm, magnif. power **6-40 X.**

2. **Improved lesion border differentiation, selection of deep surgical plane and *tridimensional control***

3. **Improved operative stability**

4. **Improved bleeding control, early visualiz. of small blood vessels**

5. **Reduced safety problems:** Lenses and facial mask protect the operator from smoke developed during surgery at the working distance

General Indications for Laser Clinical Applications

A) **Patient related** (pacemaker, contraindication for electrical instrumentation, bleeding disorders or assuming anticoagulants, contraindication of epinephrine for bleeding control)

B) **Anatomic related** (**critical sites** of the lesion for difficult surgical approach, or location particularly prone to bleeding because of the high micro-vascularization)

C) **Lesion related** (type and morphology)

D) **Technique related** (handpiece or microscope coupled, destructive or excisional, beam emission mode)

Conclusioni

Raccomandazioni Generali

- Controllo dello strumentario prima dell'uso
- Controllo caratteristiche fascio laser (watt, spot, tempo)
- Allineamento fascio (visibile) di puntamento
- Occhiali protettivi
- Abilitare la sorgente sotto controllo operatore
- Rimozione fumi (0,1μm) e vapori

Algoritmo formativo

- prove su campioni inanimati
- prove su campioni anatomici
- interventi distruttivi superficiali
- interventi distruttivi profondi
- interventi escissionali

Svantaggi

- Costo e mantenimento apparecchiatura
- Norme di sicurezza
- Curva di Apprendimento
- Minore manovrabilità del sistema operativo

Vantaggi

- Precisione, specie con controllo microscopico
- Chirurgia conservativa / minima invasività
- Assenza di suture
- Possibilità di ri-modellamento cosmetico
- Controllo della lesione neoplastica