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FEATURE ARTICLE

Picosecond Lasers - The New Gold Standard?

From Tattoo Removal to Benign Lesions and Skin Rejuvenation

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PICOSECOND LASERS – THE NEW GOLD STANDARD?

From Tattoo Removal to Benign Lesions and Skin Rejuvenation

Four years ago, we saw the introduction of the world's first picosecond laser into the global cosmetic and dermatology marketplace, but how many of us really know, and understand, what that means – both in terms of the science and for the armamentarium of the aesthetic practitioner.

Sounds quicker, but how much quicker? Sounds fancy, but just how fancy? Does quick and fancy make it a break-through? A revolution? An innovation unseen before for the medical specialty? Should we bin off the traditional Q-switched lasers that everyone has been using up until now, quite happily, to treat these indications?

In this article, we will look at just what differences a picosecond laser has over their more traditional nanosecond cousins, and the key brands and manufacturers selling devices into the UK marketplace which use this technology for tattoo removal and the treatment of benign, pigmented lesions, as well as skin rejuvenation and acne scarring.

A second - just how much time is that really?

"*Just a second*"; we all say it when we need a moment or two to complete something before our attention can be refocused onto something else. But, really, we don't mean that we only need 'one second', in fact a second is such a short amount of time, one sixtieth of a minute, that really, we need longer; yet we somehow assume that a second is all we need, like it's all the time in the world.

However, as our lives, and the technology in our lives has advanced, a second has in fact become quite a long period of time.

Usain Bolt currently holds the world record for the fastest 100m runner, achieving the time of 9.58 seconds in 2009. Even measuring the speed with which a human being can run can now be accurately measured to a tenth and a hundredth of a second. Such measurements are accurately referred to as a decisecond and a centisecond – not words that appear in normal parlance I grant you, but we accept that we understand these fractions of a second.
Pipping your opponent to a win by such fractions elevates you from zero to hero, so a tenth or a hundredth of a second can therefore seem much longer to us all.

It is now quite commonplace to hear the word millisecond, or one thousandth of a second, quoted in everyday life. A common housefly for example takes around 3 milliseconds to flap its wing. A blink of a human eye is more likely to be around 300 to 400 milliseconds, or around a third of a second. And, the average human resting heart cycle time is 860 milliseconds. A 'jiffy', yes it's a real amount of time, is defined as 10 milliseconds.

But, it's when it comes to technology that these fractions of a second begin to become more impressive than those in nature. An LCD computer monitor has a typical response rate for updating its screen of between 2 and 5 milliseconds. The shutter speed for a standard camera is between 4 and 8 milliseconds.

Yet, if that lot seems fast to you then how about a microsecond, or one millionth of a second, or one thousandth of a millisecond. That's the length of time of a high-speed, commercial strobe light flash. Such high-speed flashing of lights, hundreds of times in every second has the ability to make it appear that motion has stopped or is in slow motion.

And it doesn't stop there, a nanosecond, certainly sounds like more familiar territory when we come to talking about measures of laser light. It is in fact one billionth of a second. Whether it's nanoparticles or nanoseconds, this small measure is a sign that we are all now understanding that our technology is getting smaller and smaller and faster and faster. The symbol for nanosecond is ns.

After that comes the picosecond, or one trillionth of a second (or one millionth of one millionth of a second), which is 0.000 000 0001 seconds. Quite a bit quicker even than Usain Bolt! The symbol for nanosecond is ps.

Medical aesthetics is now embarking on the use of laser energy emitting devices which can deliver and target the energy in nanosecond as well as picosecond time periods.

Yet, picosecond lasers are not the fastest lasers in use in medicine, with femtosecond, one quadrillionth of a second speed lasers used in LASIK laser eye surgery for the creation of the flap needed to access the inner cornea.

So, let's just remind ourselves with some laser basics...

Back to Laser Basics

LASER or Light Amplification by the Stimulated Emission of Radiation were first used in medicine as far back as 1960 when the first Ruby systems were introduced and used in cardiovascular surgery. Not long afterwards, lasers started to be used in cosmetic dermatology to treat birth marks using Argon and Carbon Dioxide lasers. Following early mistakes, and rapid developments in the last 20 to 30 years, the use of lasers in the medical aesthetic specialty is now commonplace for treating a variety of indications from hair removal and skin rejuvenation to vascular or pigmented concerns, and for the removal of tattoos.

Laser, which can refer to both the equipment that emits the light or to the light itself, is basically a way of converting one type of energy into another – converting electrical energy into light energy. To do this, materials such as crystals or gases can be stimulated and made to emit radiation or light, then mirrors can be used to amplify it and thus target it as a laser beam which can then be delivered as required for treatment of different target tissues.

The wavelength of the laser light is measured in nanometers (nm) or a thousand millionth of a metre. It refers to the distance from peak to peak or trough to trough of a wave of light, which tells us whereabouts on the electromagnetic spectrum the light energy sits, such as ultra-violet (UV) light, visible light or infra-red light. The wavelength of light also determines its colour, the things that it is attracted to and its depth of penetration.

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Commonly available and used lasers in medical aesthetics include:

- Gas, e.g., carbon dioxide (CO_2) or excimer;
- Solid state, e.g., Ruby 694nm, Alexandrite 720-800nm, Neodymium Yttrium Aluminium Garnet or Nd:YAG 1064nm, frequency double Nd:YAG commonly called KTP 532nm, and Erbium YAG, Er:YAG or Er:Fibre 2940nm;
- Liquid, e.g., various dye lasers;
- Semiconductor, e.g. diode lasers 670 -1551nm.

As mentioned, the wavelength or colour of the laser light emitted dictates their associated chromophores or absorption partners, i.e. the things within tissue that they are attracted to, such as haemoglobin, melanin, pigment or water.

When it comes to tattoo removal, the chromophore is the colour of the ink. As tastes for tattoos and technology has moved on, this has meant an increase in the available pigment colours now used in tattoo art; meaning that black and dark blue tattoos are no longer the norm, which in turn has led to the search for laser technology to match it for removal treatments. Thankfully a broad spectrum of laser wavelengths exists and each has their preferred colour partner.

- 1064nm Nd:Yag treats black and some dark colours;
- 755nm Alexandrite treats green, blue, violet and black colours;
- 694nm Ruby treats green, blue, violet and black colours also
- 650nm from a dye filter attached to an Nd:YAG treats green;
- 585nm from a dye filter attached to an Nd:YAG treats blue;
- 532nm from a frequency doubled Nd:YAG or KTP treats red, orange, plus some yellow and green colours.

It is true to say, therefore, that if a practitioner wants to have the capacity to treat a wide range of tattoo colours effectively, they will need various wavelengths of laser at their disposal, ideally a minimum of three, such that there is a 532nm for treating warm toned colours, a 694nm or 755nm for treating cool toned colours and resistant of recalcitrant black inks and a 1064nm for treating black and dark skins. Importantly this will give a spectrum to treat all skin types safely too.

Other factors which govern the use of laser light in medical applications include the amount of energy delivered and the spot size of the laser beam or concentration of the beam of light – a larger spot size will spread light over a greater area and a small one will concentrate it, this determines the thermal impact of the laser beam. These two factors are interlinked as the fluence, which is measured in Joules (J) per centimetre squared as a factor or the power multiplied by time and divided by the spot size. Thus the spot size directly influences fluence.

Another differentiation for laser equipment comes with their associated typical pulse durations which can be millisecond, nanosecond or more recently the development of picosecond pulses for medical applications.

Pulse duration refers to the length of time that the laser beam is 'on'. The pulse duration is significant in determining how tissue will react when exposed to the energy from a given wavelength of light. Put simply, we refer to long pulse durations (in milliseconds) providing gentler heating up of tissues and shorter pulse durations (in nanoseconds) giving increased heating and some mechanical effects, with ultra-short pulse durations (in picoseconds) giving a rapid hit of energy which will cause a shattering or 'blowing up' reaction. This is the difference between photothermal and photomechanical or photoacoustic effects from the delivery of the laser energy.

In order to modulate the beam of laser light to produce very short pulse durations, or ultra-short pulses, instead of a continuous wave, a laser system is Q-switched. This effectively puts a clever filter in the laser cavity which prevents the laser being emitted but allows the build-up of the energy within the cavity. This filter is then suddenly removed, much like the analogy of a shutter on a camera, and the burst of 'concentrated' laser energy is released as an extremely short pulse of light.

The duration of laser energy pulses affect which treatments are performed with which variation of pulse durations.

With longer pulse durations, in the milliseconds, treatments such as hair removal are performed. During this the melanin in the hair is more slowly and gently heated up through absorption of the laser light, and then through a process of conduction in the region it destroys the foundations of the hair follicle, thus ceasing growth.

With shorter pulse durations, in the nanoseconds, treatments such as tattoo removal are performed. This is still a heating effect as the laser light is absorbed into the pigment or dye molecules within the tattoo ink and heats them up causing destruction. However, unlike millisecond pulsed lasers, the nanosecond pulse is a million times shorter so this heating happens much faster and goes on to cause a shock wave effect in the molecules which breaks them apart as the photothermal action turns into a photoacoustic action of shattering.

This photomechanical action is further increased in effect with picosecond lasers where the speed of the pulse is one thousand times shorted than a nanosecond. This means that the heating effect is essentially removed, (as there is simply no time for it to happen), as the physical 'blow' is so quick, and so sharp, that the damage to the pigment is achieved through mechanical pressure and acoustic effects, and not through heat.

General knowledge within the field tells us that when it comes to tattoo removal, one must treat with a pulse width shorter than 10ns. This is the thermal relaxation time of a typical 0.1µm tattoo ink particle. Treating with longer pulses than this just results in heating of the tattoo ink particle, and the surrounding area, and does not cause fading on the tattoo, but can produce scarring. Thus, the shorter, sub-10 nanosecond pulses are needed so that the ink particle is heated so fast that it shatters.

This means that when it comes to tattoo removal, Q-switched nanosecond pulsed lasers had been considered the gold standard for many years.

As they are in line with the optimum short pulse width highlighted above, they are effective in breaking down the pigment or ink particles for the body to eliminate but nowadays are considered slow, with multiple treatment sessions required to 'break down' the particles, and are also somewhat painful for the patient.

Picosecond lasers deliver a pulse which is one hundred times shorted than a nanosecond laser, and it is this which changes it from a photothermal plus photomechanical action to a purely photomechanical action using pressure and acoustics to have a shattering effect on pigment and ink particles. After a few years of active use, picosecond lasers are therefore knocking on the door of the gold standard for tattoo removal. The other factor which makes them attractive, and which is better news for the patient, is that generally half the fluence is required, compared to nanosecond lasers, meaning that there will be a reduction in treatment pain.

What's on The Market?

Like many devices in the aesthetic medicine and cosmetic dermatology marketplace, as soon as one 'flagship' device is launched, then the other niche manufacturers get out their R&D cheque books and start working on similar, but ultimately hopefully better technology to mimic, replicate and steal market share for the innovation. And this is precisely where we are now. The devices below are not ordered alphabetically or randomly, but in a semblance of chronology and to tell a story about the evolution of the picosecond laser marketplace.

PicoSure

The PicoSure™ laser from Cynosure has the title of being the first picosecond aesthetic laser to hit the marketplace, both for laser tattoo removal and benign, pigmented lesions. The manufacturers like to claim that it is the number one picosecond aesthetic laser in the world, having made the biggest headway in tattoo removal use and being the fastest and more

comfortable than any other method.

PicoSure doesn't use heat to destroy the tattoo ink, but ultra-short (picosecond) laser pulses which bombard the ink particles within the tattoo at very high pressure, using their PressureWave™ technology. The rapid delivery of the pulses causes the ink to break down and literally shatter into dust sized particles. Such destruction makes it much easier and quicker for the body to absorb and eliminate the debris. So much so that they claim that in one session significant clearance of darker ink tattoos can be achieved with 75%+ removal, with full removal after between 4 and 8 sessions, or 6 to 10 months.

Thus, the mode of action of the PicoSure device is not photothermal but photomechanical due to the ultra-short pulse duration and their patented PressureWave™ technology.

A PicoSure Boost™ Adjustable Pressure is also available which allows the practitioner to change the pressure and output energy to increase this shattering effect for particularly stubborn tattoos.

It hit the U.S. marketplace before it came to Europe, an unusual route compared to many aesthetic devices. It's true to say that the development of the PicoSure device, into the platform it is today, has been an incremental one.

U.S. FDA clearance was first given in December 2012 for the 755nm wavelength Alexandrite handpiece for the removal of tattoos and pigmented lesions (using the FOCUC lens array) in skin types I - VI. The 755nm hand piece is ideal for treating black, green and blue ink coloured tattoos and European launch followed swiftly with CE approval in 2013.

The system gained much interest and praise and further indications were approved for it in America, including acne scarring in July 2014 and wrinkles in September 2014 with the addition of a FOCUS lens array for skin types I – IV. This add-on microscopically concentrates the PicoSure pulses twenty times to a precise depth for specific skin rejuvenation targets and to stimulate cell signalling and an inflammatory healing response.

Subsequently in February 2015, the device became dual-wavelength with the FDA approval of the 532nm wavelength frequency doubled Nd:YAG which expanded the treatment capacity to effectively treating yellow, orange and red ink colours within tattoos in skin types I - III.

Finally, in May 2016, the 1064nm wavelength Nd:YAG was introduced and approved by the FDA to allow the removal of the full spectrum of tattoo inks in skin types I - VI, including dark tattoo inks, making the device a multi-wavelength option. The Nd:YAG has a history as a long-standing, and commonly used wavelength

for targeting tattoo removal and pigmentation concerns.

The picosecond delivery of PicoSure is between 550 and 750ps, with pulsed energy of 165 – 200mJ. The device comes with fixed spot sizes of 6mm, 8mm and 10mm and a zoom option between 2mm and 6mm.

Initial studies of the 755nm Alexandrite, such as **Saedi et al** in December 2012 showed that the device was safe and effective with all 12 patients in a study achieving greater than 75% tattoo clearance and 9 greater than 75 after 2 to 4 treatments, with an average of 4.25 treatments required. All patients were satisfied or extremely satisfied with their outcome. With regards to adverse events, they mostly included pain, swelling and blistering which resolved either immediately in the case of pain or within 1 week. Hypopigmentation was also reported.

Further published studies have focused on the success of targeting differing colours of tattoo inks, such as green, blue and yellow. One study by **Alabdulrazzaq et al**, published in April 2015, looked at the use of the PicoSure frequency doubled Nd:YAG hand piece on a small cohort of 6 patients with yellow pigmented tattoos. Results showed that 1 person achieved complete clearance after 1 treatment session, with the remaining 5 requiring between 2 and 4 sessions to achieve over 75% clearance. The authors concluded that, "*This is the first case series that demonstrates effective and consistent reduction of yellow tattoo ink using a frequency doubled Nd:YAG 532-nm laser with a picosecond pulse duration. Treatments were well tolerated and subjects had positive outcomes.*"

A review of the available clinical literature on PicoSure was undertaken by **Torbeck et al** and published in May 2016. The study reviewed ten published clinical articles and noted that; "*...the majority of studies showed that picosecond lasers are an effective and safe treatment mode for the removal of tattoo pigments. Several studies also indicated potential novel applications of picosecond lasers in the removal of various tattoo pigments (e.g., black, red, and yellow). Adverse effects were generally mild, such as transient hypopigmentation or blister formation, and were rarely more serious, such as scarring and/or textural change. Computational modelling provides evidence that the optimal pulse durations for tattoo ink removal are in the picosecond domain. It is recommended that the PicoSure laser system continue to be used for safe and effective tattoo removal, including for red and yellow pigments.*"

PicoWay

PicoWay from Syneron Candela was launched into the UK marketplace two years after the PicoSure in 2015, having gained U.S. FDA approval for treating all tattoo colours in November 2014 - red, yellow, orange using a 532nm and black, brown, green, blue and purple using a 1064nm wavelength. In April 2015, it gained further approval for the treatment of benign, pigmented lesions. PicoWay is suitable for all skin types.

The PicoWay was therefore a dual-wavelength device combining a frequency doubled Nd:YAG 532nm and a 1064nm Nd:YAG. The device is also available with a holographic fractionator, the Resolve™ upgrade, giving it both fractional and non-fractional capabilities when targeting pigment and tattoo ink within the skin. This addition was a first for the aesthetic marketplace. The Resolve upgrade is predominately indicated for skin rejuvenation treatments and the improvement of acne scarring.

But, that's not the end of the story, as a matter of months ago, in July 2016, the device became multi-wavelength with the approval of a third wavelength by the U.S. FDA. This 785nm wavelength claims to be the first of its kind in the aesthetic market as it uses a titanium sapphire laser for the removal of blue and green inks.

This additional clearance was founded on a study of 15 patients with 18 tattoos containing blue and green inks by Eric F. Bernstein MD et al. The evaluation of tattoo clearances was performed blind by a panel of independent American physicians and

showed that 83% of the treated blue/green tattoos had good to complete removal after 2 treatment sessions with PicoWay. The study also reported no treatment complications and none to mild discomfort, for the majority of patients.

The manufacturers also claim that PicoWay delivers the shortest pulse duration and the highest peak power of any picosecond aesthetic device on the market, making treatments both quicker and more comfortable for patients, whilst minimising the risk of side effects.

The picosecond delivery of PicoWay is 300ps for the 785nm, 375ps for the 532nm and 450ps for the 1064nm, with pulsed energy of 200 – 400mJ. The device comes with zoom spot sizes of 2, 3, 4, 5, 6, 7, 8, 9 and 10mm. The Resolve handpiece provides a 10 x 10 microbeam array with up to 3.0mJ micro beam energy, with a spot size on 6mm x 6mm.

With picosecond pulses, which they note are 40% shorter than their

competition, Syneron Candela claim to offer superior efficacy, safety and comfort. The ultra-short pulses enable a much strong photoacoustic effect on the ink particles using lower fluences and thus offers better clearance in fewer treatments. Combined with the highest peak power which delivers effective energy over the broadest range of spot sizes. They note that the high peak power of the 450ps PicoWay delivers 4.5 times more photoacoustic effect that the 750ps pulse of its competitor PicoSure. It therefore argues that the 750ps pulse has an increased photothermal effect than it does, which can lead to an increase in potential side effects.

A previous study by **Dr Bernstein** published in July 2015, showed the original dual-wavelength 350ps 532nm and 450ps 1064nm system to be safe and effective in removing decorative tattoos. The study treated 31 decorative tattoos in 21 patients with the two PicoWay wavelengths. Evaluated randomly by blind assessors, results showed a 79% clearance after an average of 6.5 treatments. Of the 31 tattoos, 6 showed signs of mild hyper or hypo-pigmentation.

A case report by **David Friedman MD**, published in the journal of Dermatologic Surgery in September 2016, also highlighted the advances such technology gives for tattoo removal in patients of colour. His report looked at the successful treatment of a red and black professional tattoo using the PicoWay system on a 29-year-old woman of Ethiopian descent with skin type VI. Developments and cases like this note how the limitations of nanosecond pulsed lasers can be overcome with the use of high peak power picosecond lasers for tattoo removal.

EnLIGHTen

The enLIGHTen™ by Cutera claims to have been the world's first picosecond, and nanosecond aesthetic laser featuring dual high-powered wavelengths with dual pulse durations. It was cleared by the U.S. FDA for the treatment of benign pigmented lesions in August 2014 and for tattoo removal later in November

2014. The device was not launched into the UK however until early 2016.

It combines a 532nm and 1064nm laser with 750ps pulse duration, as well as a 2ns option. This pico + nano technology offers delivery of pulsed energy of 300mJ for the 532nm and 600mJ for the 1064nm, which the company point out is 3 times greater energy than the PicoSure 1064nm offering and 1.5 times greater than its 532nm offering. The enLIGHTen device comes with spot sizes between 2 and 8mm. It is indicated for all skin types for the 1064nm and types I – III for the 532nm.

The ability to deliver high pulsed energy, with the variable pulse durations, across both wavelengths is aimed at giving practitioners the ability to optimise treatment parameters for tattoo removal and lesion treatment. The company notes that the pivotal FDA study which led to their approval demonstrates the validity in combining and using both nanosecond and picosecond pulses for treatment.

The PICO Genesis™ treatment branding also offers a non-thermal route to treating pigmentary lesions and aesthetic concerns for skin rejuvenation using the same dual wavelength technology of enLIGHTen.

Discovery Pico

The Discovery Pico and Pico Plus available from Lynton Lasers has been around in Europe since mid-2015 and is blazing a trial as the next generation in picosecond laser platforms, following in the footsteps of the pioneering technology, but improving and bringing new ideas to the marketplace.

It has been developed by the Italian company Quanta Systems. Commercialised in the United States by the American branch of the company Quanta Aesthetic Lasers, it is marketed there as Prima Pico and Prima Pico Plus and FDA approval was granted for this U.S. brand in April 2016.

The PICO SERIES, as it is also referred to, claims to transcend all conventional, stand-alone picosecond lasers by combining the new efficacy and speed that picosecond brings, with the proven safety and efficacy of long-standing nanosecond Q-switched technology.

It features a 532nm frequency doubled Nd:YAG (KTP) laser and a 1064nm Nd:YAG, both capable of picosecond and nanosecond output. The picosecond delivery of the PICO SERIES is 370ps for the 532nm and 450ps for the 1064nm, with both also able to deliver 6ns pulse durations of a more traditional nature.

The devices come with a variety of spot sizes and tip formations, including 2mm, 4mm and 6mm round tips and squared shaped tips of 2 x 2, 3 x 3, 4 x 4 and 5 x 4mm2. The spot shape and handpiece tips are based on their OPTIBEAM® II technology.

The square spot profile is said to allow safer and more effective treatments than traditional spot shapes, due to the homogeneous energy distribution over the treated area, which results in less skin trauma, and decreases the risk of side effects, hot spots, as well as unwanted overlapping of treatment.

It does this as the OPTIBEAM II handpiece ensures a perfect FLAT TOP beam profile which allows it to distribute the power of the laser homogeneously across the output beam profile.

This offering also provides the world's first to include a nanosecond (30ns) 694nm Ruby laser alongside the pico and nano technology to provide a multi-treatment solution, giving the option to treat and remove notoriously tricky green and red inks. This is available with the Discovery Pico Plus model.

Despite the claims by Syneron Candela's PicoWay, Lynton Lasers dispute it and claim that they now have the industry's highest peak power system, offering 1.8 Gigawatts maximum. They also note that they have this in combination with one of the shortest pulse durations available on the market. This combination is said to produce the optimum photomechanical effect in shattering tattoo pigments quickly.

This combined system allows the platform to achieve all the photothermal and photomechanical modes of action from a single device – with picosecond pulses, Q-switched and free-running pulse emission options.

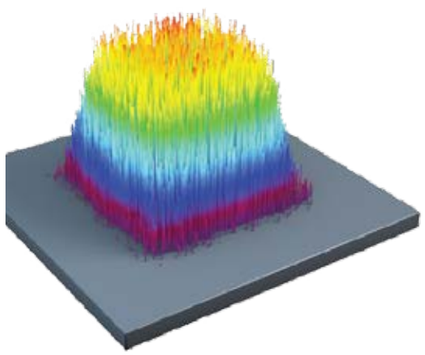
An additional benefit comes from the add-on of the FraxTip™ Lens, an 8mm fractionated round tip, which can be used for the skin rejuvenation treatments that benefit from this technology. This lens concentrates the energy generated by the laser to produce the photomechanical trauma in the epidermis which stimulates the healing response and collagenesis, without producing any thermal damage.

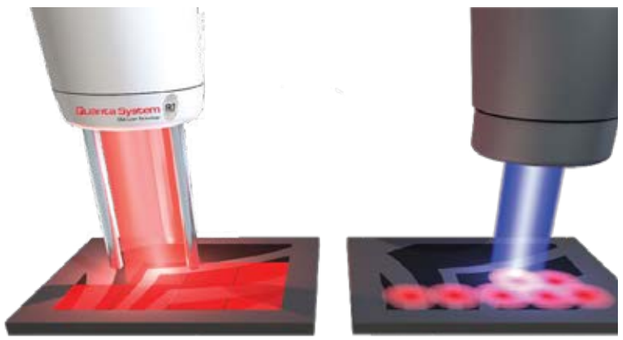
PicoClear

This is the offering from Alma Lasers which began marketing in the USA just this last summer. As yet, it is unavailable in the UK marketplace but set to launch in early 2017, according to ABC Lasers Ltd, the UK distributor for Alma Lasers.

The PicoClear features dual-wavelengths with a 532nm KTP laser and a 1064nm Nd:YAG producing both nanosecond and picosecond pulse durations. The device also comes with fractional control systems for skin rejuvenation applications, plus a variety of spot sizes.

Although not part of the main PicoClear platform, the company are actively marketing the combined purchase with a stand-alone 684nm Ruby laser as a package deal.





Comparison Chart

As is often the case with comparing any technology, from televisions to medical aesthetic lasers, it can be a minefield of specifications, add-ons and reviews, or in this case clinical data. To make it a little easier to compare the current crop of picosecond lasers, here is a comparison chart of key parameters that we were able to identify from available manufacturer specification information.

MANUFACTURER	DISCOVERY PICO LYNTON LASERS LTD / QUANTA AESTHETIC LASERS			ENLIGHTEN CUTERA LASERS		PICOSURE CYNOSURE			PICOWAY SYNERON CANDELA		
WAVELENGTH	532nm	694nm	1064nm	532nm	1064nm	532nm	755nm	1064nm	532nm	785nm	1064nm
LASER TYPE	DOUBLED Nd:YAG (KTP)	RUBY	Nd:YAG	DOUBLED Nd:YAG (KTP)	Nd:YAG	DOUBLED Nd:YAG (KTP)	ALEXANDRITE	Nd:YAG	DOUBLED Nd:YAG (KTP)	TITANIUM SAPPHIRE	Nd:YAG
ENERGY DELIVERED	200mJ (800mJ)	1200mJ	400mJ (800mJ)	300mJ	600mJ	165mJ	200mJ		200mJ		400mJ
PEAK POWER	0.8 Gigawatts (67 Megawatts)	40 Megawatts	1.8 Gigawatts (133 Megawatts)	0.4 Gigawatts	0.8 Gigawatts		0.36 Gigawatts		0.53 Gigawatts		0.9 Gigawatts
PULSE DURATION											
Picosecond	370ps	_	450ps	750ps	750ps	550ps	750ps		375ps	300ps	450ps
Nanosecond	6ns	30ns	6ns	2ns	2ns	_	_	_	_	_	_
FLUENCE	12J/cm2	_	25J/cm2	0.5J/cm2 - 2.5J/cm2	1.1J/cm2 - 10J/cm2	UP TO 1.1J/cm2					
SPOT SIZE	2MM, 4MM AND 6MM ROUND, PLUS 2 X 2MM, 3 X 3MM, 4 X 4MM AND 5 X 5MM SQUARE			2MM - 8MM		2MM - 6MM ZOOM AND FIXED 6MM, 8MM AND 10MM			2MM - 10MM		
ADD-ONS	FraxTip LENS 8MM FRACTIONAL ROUND TIP			PICO Genesis BRANDING FOR SKIN REJUVENATION		FOCUS LENS ARRAY			RESOLVE (HOLOGRAPHIC FRACTIONATOR) - UP TO 3.0mJ MICRO ENERGY BEAM, 6MM X 6MM SPOT SIZE		
	RUBY HANDPIECE AVAILABLE ON DISCOVERY PICO PLUS MODEL ONLY										

Conclusion

American Q-switched laser manufacturer Astanza, who specialise in lasers for tattoo removal, recently wrote in a **blog** on their website that, understandably, they aren't too impressed with picosecond lasers for tattoo removal.

They stated; "*Picosecond Q-switched lasers are touted for removing tattoos faster than nanosecond lasers – insisting that pulse duration is the determining factor for fast tattoo removal. However, not only do picosecond systems with their shortened pulse durations not provide any significant peak power benefit over high-end nanosecond lasers, both types of systems shatter ink in qualitatively the same way.*"

They go on to say, "*Picosecond systems are vastly underpowered compared to nanosecond systems, forcing practitioners to use small spot sizes when fluence levels need to be increased.*

While shortened pulse durations theoretically have a benefit for peak power, the benefit only exists if all other specifications (particularly pulse energy) are kept constant – and producing picosecond lasers with high pulse energy have proven to be both difficult and prohibitively expensive. Because of these difficulties, the picosecond systems that have made it to market have not delivered on their marketing promises and are plagued with reliability issues."

This company is not the only one to openly have a pop at picosecond lasers. Over in America, a **class action lawsuit** is taking shape in Chicago against Cynosure. The suit accuses them of false advertising relating to the PicoSure tattoo removal system. The company is said to have sold devices to a number of dermatology practices across the country, since FDA approval in 2012, and alleges that although the company advertises that the machine removes tattoos and shows pictorial results, the machine does not do so. It goes on to say that the practices involved in the class action purchased the PicoSure under the belief that it would remove tattoos and that when they began to raise questions regarding the efficacy and safety of the product, Cynosure continued to make misrepresentations regarding the device, and refused returns and refunds. According to the **law firm** fronting the class action, it is currently pending in the Northern District of Illinois Federal Court.

One has to say that this kind of news doesn't bode well, and if nothing else highlights the need for reliance on credible clinical evidence, over and above fancy marketing and figure-head posturing!

A systematic review of picosecond lasers for tattoo removal by **Reiter O et al**, has just been published in September 2016 in the Lasers in Medical Science journal. The authors hypothesised that picosecond lasers would be expected to be more effective than nanosecond lasers in tattoo removal.

Reviewing relevant trials from Pubmed, Cochrane Central Register of Controlled Trials and ClinicalTrails.gov they analysed eight specific trials (6 human and 2 animal) and noted that they mostly varied in terms of the type of laser investigated, including 755, 758, 795, 1064 or 1064/532nm, and that the trials were mostly non-comparative studies, looking at the treatment of black and blue ink tattoos, with a medium to high risk of bias.

The conclusion to their review is perhaps a little telling, and certainly shows that further study is required, particularly comparative data. The authors stated; "*There is sparse evidence that picosecond lasers are more effective than their nanosecond counterparts for mainly black and blue ink tattoo removal.*"

Now there is some comparative, historical data available but it is sparse. One of the most quoted when discussing this subject was published in 1998 (yes you did read that date correctly), in the Archives of Dermatology. In this study, **Ross V. et al** looked at the comparison of responses of tattoos to picosecond and nanosecond Q-switched neodymium: YAG lasers, and treated 16 patients with black tattoos. All parameters for treatment were kept the same, apart from the nanosecond and picosecond pulse duration. Results showed that in 12 of 16 tattoos, there was significant lightening in the picosecond-treated areas compared with those treated with nanosecond pulses. The authors therefore concluded that picosecond pulses are more efficient than nanosecond pulses in clearing black tattoos. It's fair to say that it is this kind of foundational data which has led us to where we are now, but as we know, tattoos are no longer all black, so there is still much research left to do and claims to substantiate.

More comparative data is starting to emerge with **one paper** accepted for publication by the British Journal of Dermatology, yet to be published, entitled "*Nd:YAG (1064-nm) picosecond laser vs. Nd:YAG (1064-nm) nanosecond laser in tattoo removal: A randomized controlled single-blind clinical trial*". As yet we cannot know the conclusions of this particular study, but it certainly bodes well to see that clinical evaluation is starting to emerge which draws a direct comparison of the technology. If we want to set gold standards, or in fact reinvent them, then we cannot do this without comparing 'old' with 'new'.

Devices continue to come to market, all over the globe and innovation and development of the devices is certain to mean that more and more options become available.

For example, in the USA, Zarin Medical have introduced the PiQo4 device, manufactured by Focus Medical and said to be the only FDA-cleared picosecond laser with 4 wavelengths, (1064nm, 532nm, 650nm, and 585nm), the highest power and largest spot size! It has both nanosecond and picosecond options, and has been available in Asia for some time. It takes its names from Pi for picosecond, Q for Q-switched and 4 for 4 wavelengths. Who knows what the next innovation will be and if they will also land on our shores.

It's fair to say that picosecond lasers are not just a one trick pony and more and more clinical evidence is being published and trials ongoing into the use of the leading picosecond laser brands for the treatment of acne and acne scarring, melasma, treating patients with skin of various Fitzpatrick colour types for pigmented lesions and other pigmentary disorders.

There is certainly more evidence and experience yet to come. There are those that love picosecond laser technology for cosmetic dermatology applications, and others who are not a fan. I think therefore we just have to conclude that the jury is still out; but let's face it, the more options clinicians have, the more chance they have of creating happy patients!

Lorna Jackson, BSc.

Lorna has been Editor of Consulting Room, the UK's largest aesthetic information website since 2003. She has become an industry commentator on a number of different areas related to the aesthetic industry, collating and evaluating statistics, plus researching, investigating and writing feature articles, blogs, newsletters and reports for Consulting Room and various consumer and trade publications, including Cosmetic News, Journal of Aesthetic Nursing, Body Language, PMFA News, Aesthetic Medicine and Aesthetic Dentistry Today. Lorna has also been asked to present at various industry events, including Smart Ideas, FACE and the CCR Expo. She was awarded Journalist of the Year at the MyFaceMyBody Awards 2014.

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